dryfit-system
maintenance-free

Sonnenschein

7520 e

Sonnenschein
0719472
6 V
6,5 Ah - 6
Made in Germany

dryfit A300

Sonnenschein
0719523
6 V
9,5 Ah - S
Made in Germany

dryfit A300

Sonnenschein
0719312
6 V
3,0 Ah - S
Made in Germany

dryfit A300

Sonnenschein
3 Fx4 S
6 V
6,5 Ah
Made in Germany

dryfit A200
071 90472

Sonnenschein
6 Nx4 A
12 V
36 Ah
Made in Germany

dryfit
081 90640

Sonnenschein
6 Fx3 S
12 V
5,7 Ah
Made in Germany

dryfit A200
071 90432

Sonnenschein
3 Gx3 S
6 V
3,0 Ah
Made in Germany

dryfit A200
071 90312

A

V

Sonnenschein
Made in Germany
ULIMATIC
24 V — 10 A

FUNCTION

− +

M 6,3A   I   O

Sonnenschein
ULIMAT

dryfit-system maintenance-free

dryfit-system maintenance-free I
general data and behaviour

Sealed maintenance-free

For a long time the concepts of "requiring no maintenance" and "lead accumulators" seemed to be irreconcilable. Checking the acid level, regular topping up with distilled water and relatively frequent recharging, due to self-discharge, were always necessary maintenance operations. In addition, the battery could only be used in an upright position, could not be left discharged, and excessive discharge and over-charging had to be avoided.

In contrast, dryfit batteries require no maintenance.

Another outstanding characteristic of the dryfit battery is that it does not require over-charging in order to obtain the full capacity. As a result, the loss of water which is usual when charging lead accumulators can be reduced to such an extend that no water has to be added during the entire life of the dryfit battery. If, due to improper charging or large variations of temperature, a gas pressure builds up in the battery, the safety valves ensure that this gas can escape immediately. Afterwards, the safety valves automatically shut off the electrolyte space from the outside atmosphere. Assuming that the operating and environmental conditions are satisfactory, dryfit batteries are sealed and do not gas. They can therefore be used in Germany in accordance with the test certificate of the Physikalisch-Technische Bundesanstalt (Physics-Technical Federal Institute) in workshops which are hazarded by combustible substances of all the explosive classes within the range of inflammability groups G 1 - G 5. Their method of construction meets the requirements of VDE 0171/1.69.

Other versions of explosion proof batteries are available on request.

The property of altering the voltage and current consumption as a function of the degree of charge attained, makes it possible to control recharging automatically. This dryfit feature is very valuable, particularly in the fully charged state, since it makes possible a voltage-limited, fully automatic charging procedure which does not require any intervention on the part of the user.

Container material

dryfit batteries are assembled in containers consisting of acid-resistant high-impact ABS plastic material, according to DIN 7728, avoiding mechanical damage by its tough-resilient nature.

Terminals and their protection

Dryfit batteries are available with the quoted terminals. Naturally, because of the dimensions, not every possible combination can be used. Figure 2 shows the physical shapes. The type of terminal in question can be recognised from the letters appended to the type code, for example, A 300 — 6 V — 3,0 Ah — S. A corrosion resistant silver version is recommended for sprung mating contacts or plug connections.

Particularly on spade-type connectors, atmospheric contamination may, on the silver contacts of the positive pole, lead to the formation of layers of oxide which, in the long run, could interfere with a reliable contact. Soldered joints can also be attacked if the different metals react together galvanically in a moist environment.

It is advisable, therefore, to smear spade or soldered connections at the contact surfaces with vaseline or silicone grease.

Low self-discharge

The self-discharge of the dryfit battery is extraordinarily low. Long periods of inactivity in open circuit, which frequently occur in certain applications no longer have a detrimental effect. Whereas the conventional lead accumulator has such a high self-discharge that its use in these cases is impossible, the dryfit battery offers no problems in this respect. Hence it is eminently suitable for equipment with small or only occasional demands.

Insensitivity to orientation

dryfit batteries are insensitive to their orientation. They can, therefore be stored, charged and discharged in any position, even upside down. Whereas in older types of batteries the electrolyte is contained in a spongy separator for this reason, in the dryfit system it is held in a thixotropic mass of gel with a very low internal resistance. Each cell is sealed by a safety valve which is preceded by a double adsorbtion system to prevent the egress of moisture from the electrolyte.

In a fixed installation, one should take care that as far as possible, the valves point upwards or to the side and are not covered. During installation the electrical safety clearances must also be maintained.

Protection against deep discharge

The dryfit battery, in contrast to conventional lead batteries, is protected against deep discharge. Whilst for other systems of batteries, losses of output or cell damage often occur due to the reversal of polarity usual in the case of a deep discharge, the dryfit battery can be re-charged without any difficulty after an accidental excessive discharge. Even in the event of a unit accidentally remaining switched on for a long time so that the dryfit battery is discharged beyond its capacity, it can be recharged over a prolonged charging period. However, it is better to avoid storing fully discharged batteries longer than 4 weeks without recharging. Only for Types A 200 and A 300 12 V — 36 Ah — A is speedy recharging required after every complete discharge.

Figure 1
Self-discharge of dryfit batteries at different temperatures in comparison with a conventional lead-antimony alloy battery.

I = dryfit batteries
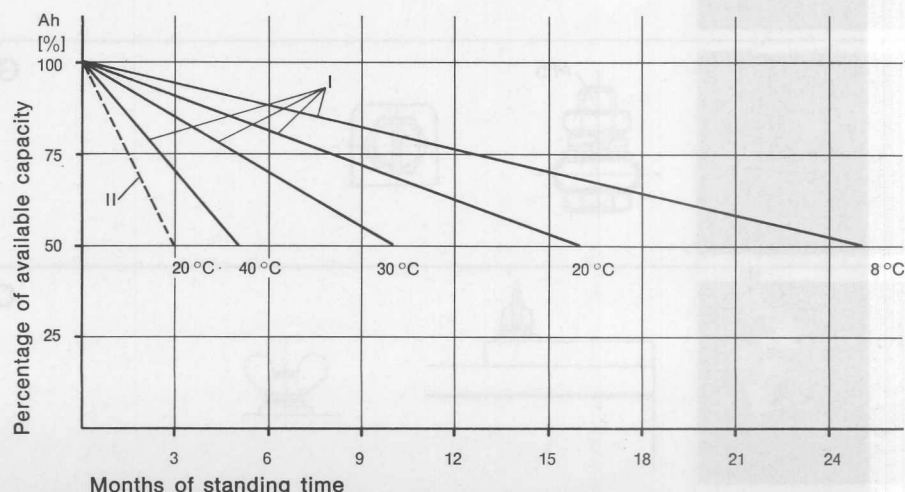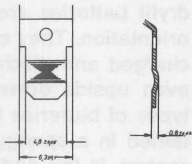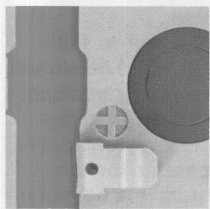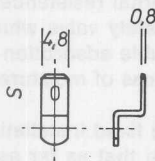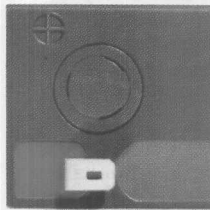II = standard lead-batteries

Fig. 2
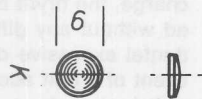Connection terminals of the various
dryfit types.

	V	silver flat contact with solder eye terminal lug for FASTON types 4.8 mm and 6.3 mm spade connector
	S	Silver flat contact with solder eye and terminal lug for FASTON Type 4.8 mm spade connector
	U	Laterally displaced, flat silver contact
	K	Silver contact rivet
	N	Silvered flat contact on the narrow edge of the battery
	A	DIN 72311 lead terminal post with central hole
	G	Drilled flat lead post. Matching bolt-on flat connectors of Type 4.8 mm or 6.3 mm are available
	C	Wingnut M 5 as per DIN 315 - mg - 4
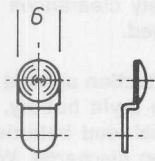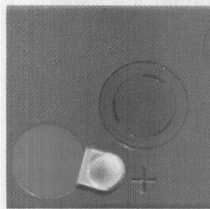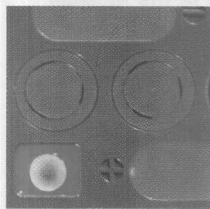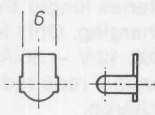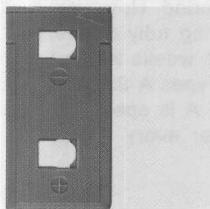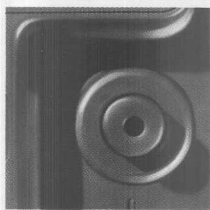
dryfit-system maintenance-free
general data and behaviour

Storage conditions

Batteries should, as far as possible, be stored in a fully charged condition. Batteries stored or kept in readiness at an average ambient temperature of + 20 °C need an additional charge after 16 months at the latest. This period is shortened at higher temperatures and extended at lower temperatures. On frequently used batteries the self-discharge may increase slight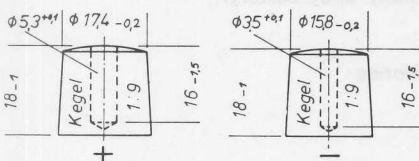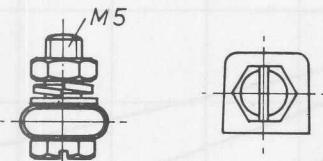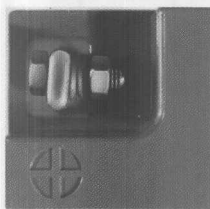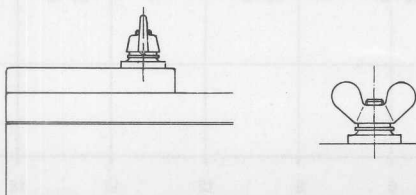ly. Since storage in the fully charged condition basically has beneficial effects on the life and stability under cycling, it is advisable to give an additional charge after storage periods corresponding to about 25 % self-discharge, as given in Figure 1.

Batteries should be stored under dry conditions since moisture leads to conducting paths between the terminals, and as a result increases self-discharge and facilitates corrosion. Since, as the state of charge reduces, the density of the electrolyte reduces and hence the freezing point rises, the charge states plotted in Fig. 3 must be observed during long storage at very low temperatures. Only in this way can possible permanent loss of capacity be prevented.

Capacity as a function of ambient temperature

The information contained in the curves in Figures 9, 11, 12 and 13 is related to an ambient temperature of + 20 °C. The curves in Figure 4 give information regarding the capacity in a wider range of ambient temperatures. Here is plotted the available capacity as a percentage of the nominal capacity at different ambient temperatures for 3 different load examples with a continuous discharge down to the relevant discharge cut-off voltage.

For the values of the upper edge of the curves, the batteries were charged at an ambient temperature of +20 °C, voltage limited to 2.3 V/cell. For the lower edge of the curves, the batteries were charged at the indicated low ambient temperature, and hence under somewhat less favourable conditions. The curves show the behaviour of the batteries after a few charging cycles.

When assessing both curves for the higher discharge currents, the dependency on the load must also be taken into account, and is already included in this graph. To prevent permanent damage to the capacity behaviour of the batteries at very low temperatures, the shaded area should be avoided. See also Figure 3 regarding storage temperatures.
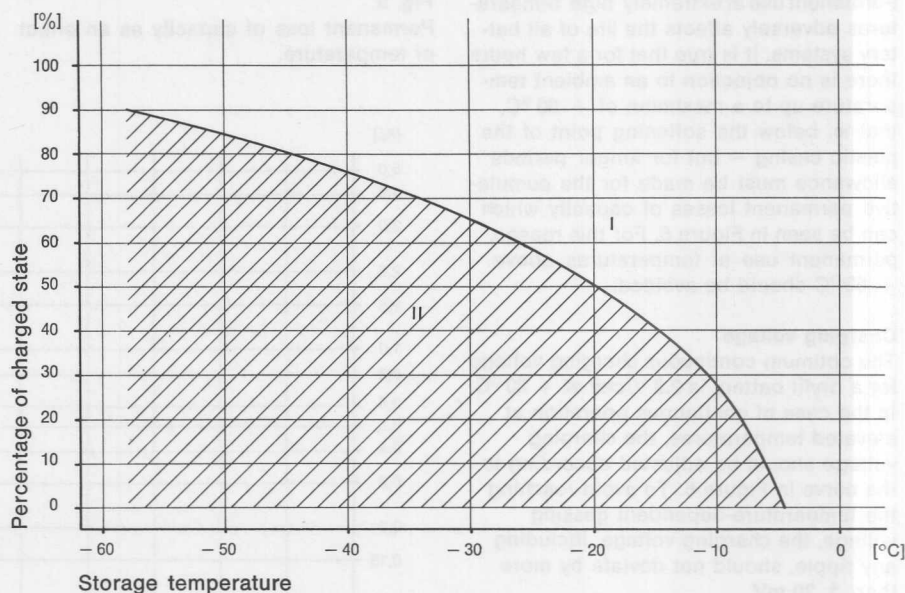

Fig. 3
Minimum charged state for storage at low temperatures.

I = Storage range
II = Prohibited range
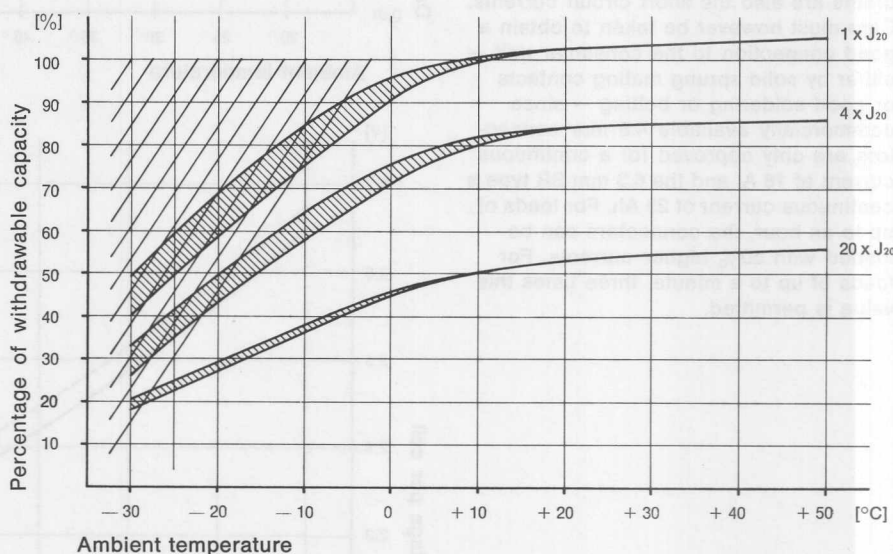

Fig. 4
Percentage of withdrawable capacity at different temperatures for 3 load examples.

Upper edge of curve:
Charging at + 20 °C. Discharge at quoted temperature.

Lower edge of curve:
Charging and discharging at quoted temperature.

dryfit-system maintenance-free
general data and behaviour

Permanent use at extremely high temperatures adversely affects the life of all battery systems. It is true that for a few hours there is no objection to an ambient temperature up to a maximum of + 80 °C, that is, below the softening point of the plastic casing — but for longer periods allowance must be made for the cumulative permanent losses of capacity which can be seen in Figure 5. For this reason, permanent use at temperatures above + 50 °C should be avoided.

Charging voltage

The optimum continuous charging voltage for a dryfit battery is 2.3 V/cell at + 20 °C. In the case of continuous operation at elevated temperatures, the charging voltage should be adjusted according to the curve in Figure 6. To avoid reaching the temperature-dependent gassing voltage, the charging voltage, including any ripple, should not deviate by more than ± 30 mV.

Load capacity

Dryfit batteries can deliver very high currents. The areas of the silver contacts located on the poles and the directly extended lead poles on some types permit full loading up to the currents quoted in the tables in Figures 8 and 15. For batteries of up to 3.0 Ah the quoted current drains are also the short circuit currents. Care must however be taken to obtain a good connection to the consumer unit — either by solid sprung mating contacts or good soldering or bolting — since commercially available 4.8 mm connectors are only approved for a continuous current of 16 A, and the 6.3 mm SR type a continuous current of 25 Ah. For loads of up to an hour, the connectors can be loaded with 50% higher currents. For loads of up to a minute, three times this value is permitted.

Fig. 5
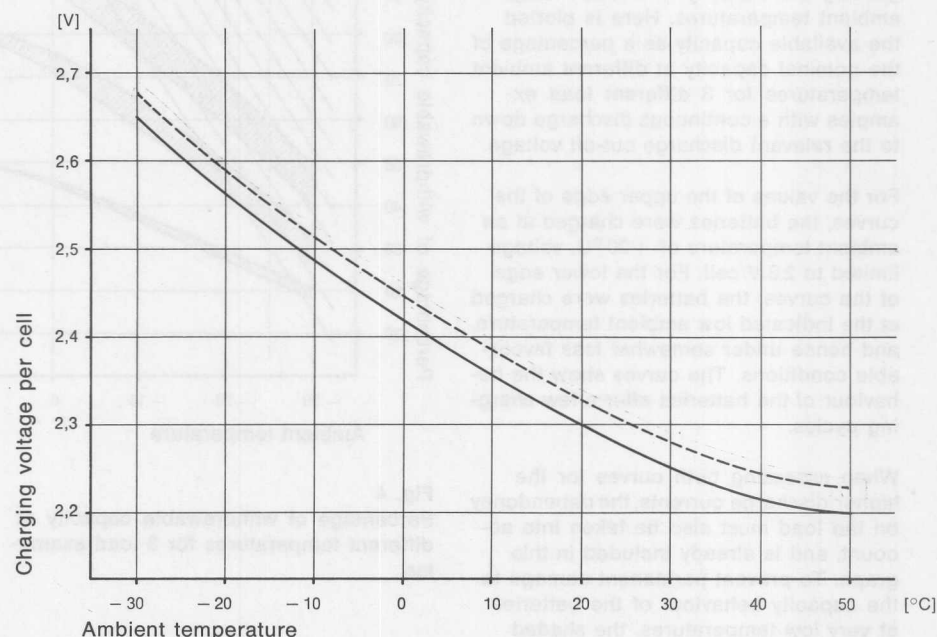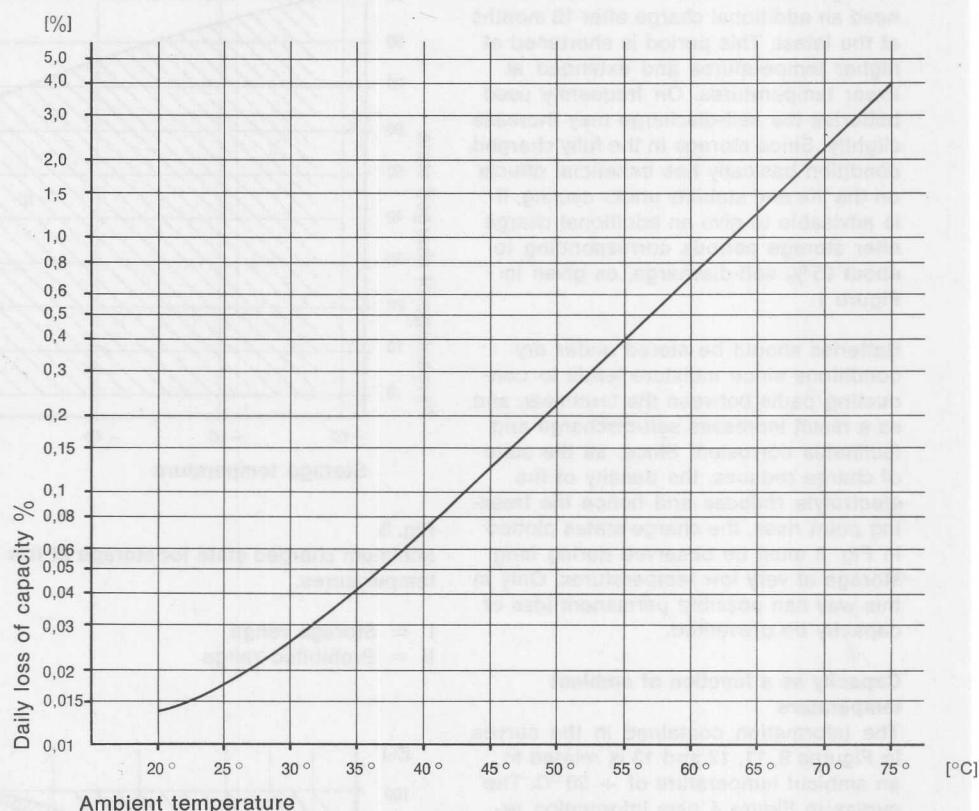Permanent loss of capacity as an effect of temperature.

Fig. 6
Dependency of the optimum final charging voltage for attaining full charge on extreme ambient temperatures. Dotted line = highest permissible, short time peak values, e. g. at superimposed a. c. ripple.

dryfit-system maintenance-free
general data and behaviour

Capacity

The capacity of a battery is given in ampere-hours. It is the product of the discharge current and the discharge time. The discharge time is limited by the drop in the discharge voltage to a prescribed minimum value, the final discharge voltage.

The battery capacity is not a fixed value but depends on the conditions under which it is extracted, these are: the magnitude of the discharge current, whether the discharge current is continuous or intermittent, the temperature during discharge and the age of the battery and its previous history.

Nominal capacity

The nominal capacity is given in accordance with international usage for different battery types or, according to application, preferably at the 10 or 20 hour rate.

The nominal capacity C_{20} is the value in ampere-hours for a 20 hours uniform continuous discharge down to the final discharge voltage of 1.75 V/cell at a temperature of $+20\,°C$. The nominal current J_{20} in amperes is thus $1/20$ of the nominal capacity in ampere-hours.

The nominal capacity C_{10} is determined for the 10 hour nominal current J_{10} in accordance with the above mentioned definition.

Before determining the capacity, a topping up charge is necessary.

Internal resistance

Quoting the internal resistance of accumulators is a difficult matter. The values depend to a great extent on the ambient temperature, the state of charge of the accumulator and its earlier history. It is of considerable importance, for example, whether the battery was connected to the charging voltage immediately before measuring the internal resistance or whether some hours elapsed between the end of the charging process and the beginning of the resistance measurements. Measurements carried out immediately after the charging process usually give higher values.

Usually, internal resistances are quoted as a. c. resistances at 50 Hz or even 1000 Hz. This is a definition which produces useful information for only very few applications. When fully charged at $+20\,°C$, dryfit cells have an internal resistance of about $30-40$ milliohms at 50 Hz divided by the 20-hour value of Ah.

The equipment designer is however usually more interested in d. c. internal resistances because he must know, when designing his equipment, the voltage output of the battery with

variations of load, and for pulse loads. Here the decisive role is played by the absolute magnitude of the normal load current and the absolute magnitude of the change of current which is inserted in Ohm's Law as the current difference when calculating the d. c. internal resistance.
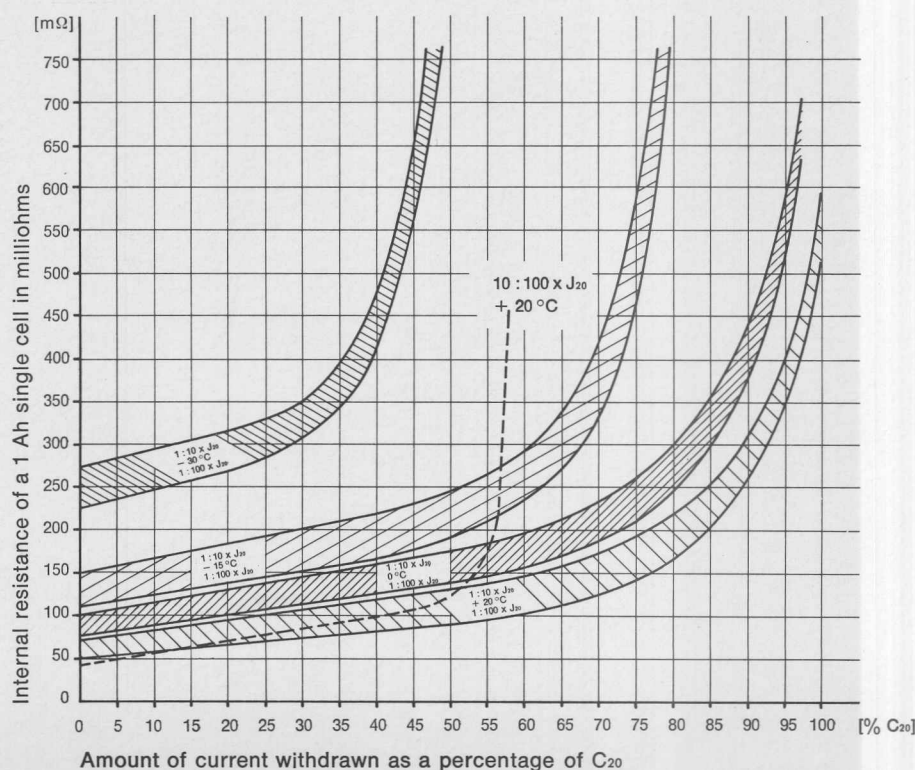
The relationships are plotted in Figure 7: It shows the internal resistance of a 1 Ah cell in milliohms as a function of the amount of current withdrawn. The lowest band shows the conditions at $+20\,°C$, the higher bands for $0\,°C$, $-15\,°C$ and $-30\,°C$. In each case, the upper edge of the band applies to a cell discharge current of $1 \times J_{20}$, which is increased to $10 \times J_{20}$ for pulses. The lower edge describes the behaviour under heavy current pulses, that is for a normal load of $1 \times J_{20}$ with a sudden increase to $100 \times J_{20}$. The resistance conditions for pulses with intermediate values can be interpolated. For batteries with capacities differing from 1 Ah, the values read from Figure 7 must be divided by the capacity and multiplied by the number of cells.

Fig. 7
d. c. internal resistance of dryfit cells.

As an example, consider a dryfit cell at $+20\,°C$, with a state of charge of $20\,\%$, that is $80\,\%$ of the capacity withdrawn. If such a cell is discharged at $1 \times J_{20}$ and is then subjected to a pulse load of $10 \times J_{20}$, it exhibits an internal resistance of 220 milliohms divided by the 20-hour Ah value. However, if the discharge current is suddenly increased from $1 \times J_{20}$ to $100 \times J_{20}$, it behaves as if it had an internal resistance of 165 milliohms divided by C_{20} which is better than for a smaller pulse.

The internal d. c. resistance does not depend only on the magnitude of the discharge pulse but also on the magnitude of the discharge current which suddenly increases by the discharge pulse. The broken curve was plotted for an ambient temperature of $+20\,°C$ and a discharge current of $10 \times J_{20}$ which increases as an impulse to $100 \times J_{20}$. In this example, for a cell in the half charged state, the result is a d. c. internal resistance of 120 milliohms divided by C_{20}. For the fully charged cell, this internal resistance under the same load conditions reduces to 40 milliohms, a value which of course increases very rapidly as the capacity becomes exhausted.

Since the internal resistance of an accumulator obviously depends very much on the design, differences occur from one type of battery to another. The curves in Figure 7 are based on a 5.7 Ah cell.

Fig. 7 — d. c. internal resistance of dryfit cells.

Internal resistance of a 1 Ah single cell in milliohms [mΩ]

Amount of current withdrawn as a percentage of C_{20} [% C_{20}]
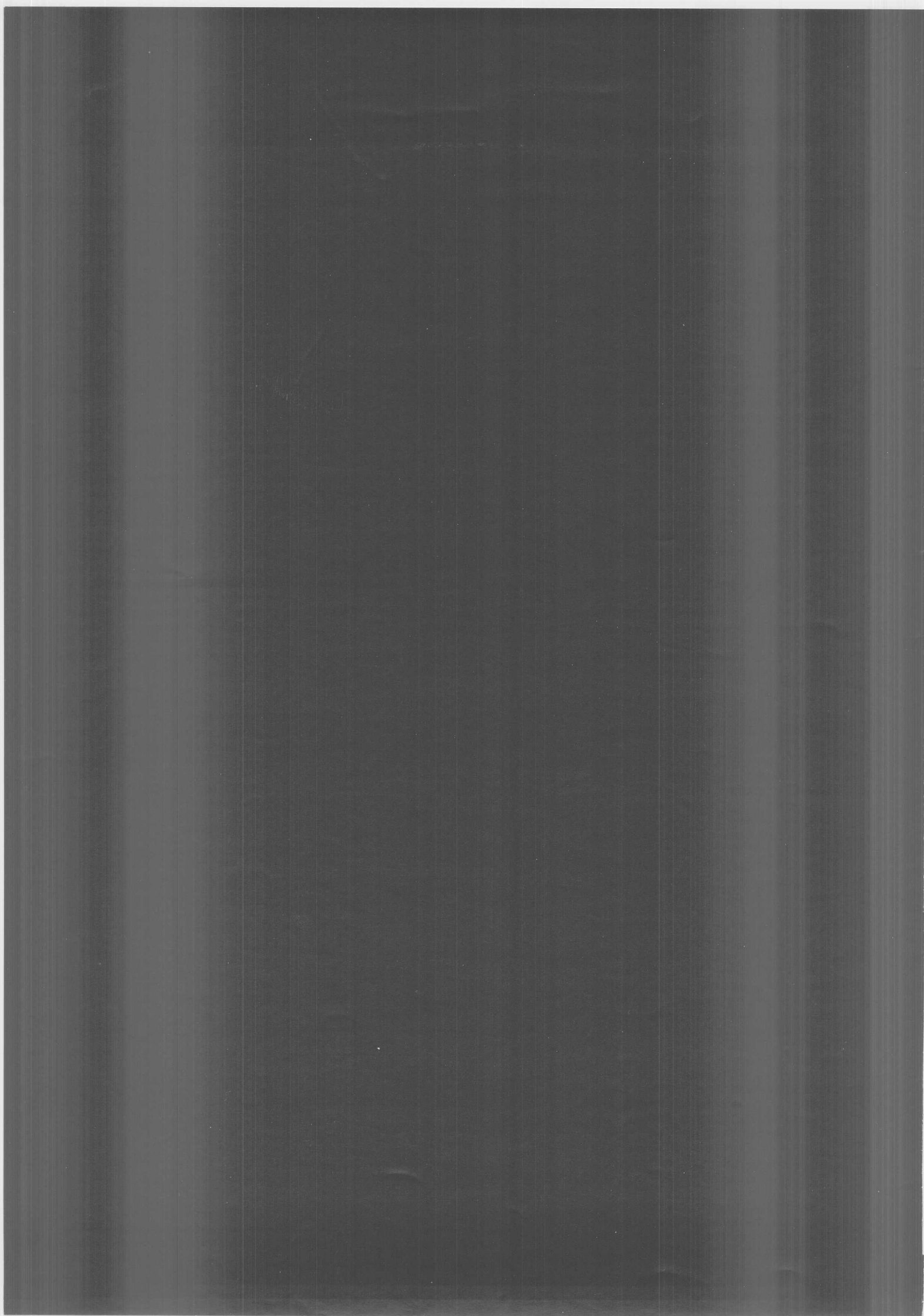
A 200 series
for high cyclic applications

A 200 series
The highest performance batteries of the dryfit range: ideal for use in top quality power supplies, in high cyclic applications involving complete discharges and for float operation with periodic deep discharges.

A 200 series
for high cyclic applications

Technical Data
(Right of modification reserved)
In the table in Figure 8, the technical data for the available A 200 series dryfit batteries are listed in tabular form. Particular references will be found in the footnotes.

Type No.	Former type code[1])	New type code[1])
07 1 90153 00	1 Ax 2 K	A 202 / 1.0 K
07 1 90163 00	2 Ax 2 K	A 204 / 1.0 K
07 1 90173 00	3 Ax 2 K	A 206 / 1.0 K
07 1 90172 00	3 Ax 2 S	A 206 / 1.0 S
07 1 90180 00	3 Cx 2 U	A 206 / 1.1 U
07 1 90182 00	3 Cx 2 S	A 206 / 1.1 S
07 1 90185 00	6 Cx 2 S	A 212 / 1.1 S
07 1 90190 00	4 Dx 2 U	A 208 / 1.1 U
07 1 90191 00	4 Dx 2 N	A 208 / 1.1 N
07 1 90193 00	4 Dx 2 S	A 208 / 1.1 S
07 1 90202 00	6 Sx 3 S	A 212 / 1.8 S
07 1 90262 00	3 Bx 3 S	A 206 / 2.0 S
07 1 90280 00	1 Gx 3 V	A 202 / 3.0 V
07 1 90302 00	2 Gx 3 S	A 204 / 3.0 S
07 1 90310 00	3 Gx 3 U	A 206 / 3.0 U
07 1 90312 00	3 Gx 3 S	A 206 / 3.0 S
07 1 90315 00	6 Gx 3 S	A 212 / 3.0 S
07 1 90322 00	4 Gx 3 S	A 208 / 3.0 S
07 1 90321 00	4 Gx 3 N	A 208 / 3.0 N
07 1 90390 00	3 Tx 2 K	A 206 / 3.8 K
07 1 90391 00	3 Tx 2 S	A 206 / 3.8 S
07 1 90400 00	4 Fx 2 S	A 208 / 3.8 S
07 1 90421 00	1 Fx 3 V	A 202 / 5.7 V
07 1 90466 00	3 Fx 3 U	A 206 / 5.7 U
07 1 90465 00	3 Fx 3 S	A 206 / 5.7 S
07 1 90432 00	6 Fx 3 S	A 212 / 5.7 S
07 1 90435 00	6 Fx 3 C	A 212 / 5.7 C
07 1 90472 00	3 Fx 4 S	A 206 / 6.5 S
07 1 90502 00	1 Fx 5 S	A 202 / 9.5 S
07 1 90523 00	3 Fx 5 S	A 206 / 9.5 S
07 1 90525 00	6 Fx 5 S	A 212 / 9.5 S
07 1 90550 00	6 Px 4 G[4])	A 212 / 12 S
08 1 90602 00	6 Mx 6 SR[3])	A 212 / 20 SR
08 1 90604 00	6 Mx 6 G	A 212 / 20 G
08 1 90640 00	6 Nx 4 A[4])[5])	A 212 / 36 A
08 1 90700 00	6 Nx 7 G	A 212 / 63 G

Fig. 8
A 200 series dryfit batteries, range of products and technical data.

1. The last letter of the type code indicates the type of terminals, as shown in Figure 2.

2. Only with suitable mating contacts. See the section on "Load capacity" in the text.

3. Obsolescent types. Do not use battery with SR contacts for new designs.

4. These 12 V 12 Ah and 12 V 36 Ah batteries exhibit somewhat different behaviour as regards capacity because of their constructional features. As a result, new batteries can only achieve the full 20-hour nominal capacity after a few cycles. However, when discharged at $4 \times J_{20}$, they are the same as the standard types. When discharged at high currents they are in fact better, even when new.

5. After every full discharge-recharge again immediately.

6. Double values are allowed at a load up to 5 seconds.

dryfit-system maintenance-free

A 200 series
for high cyclic applications

Nominal voltage	Nominal capacity (C_{20}) for 20 hr. discharge	Discharge current (J_{20}) for 20 hr. discharge	Weight approx.	Dimensions Length	Width	Height to top of lid	Maximum height over contacts/ cover	Power/ weight ratio approx.	Power/ volume ratio	Max. load approx.	Interchangeable with
V	Ah	mA	g	mm	mm	mm	mm max.	Wh/kg	Wh/l	A[2]	
2	1,0	50	85	18,7	42,5	50,5	51,7	23,5	51,4	40	
4	1,0	50	170	34,9	42,5	50,5	51,7	23,5	55,2	40	
6	1,0	50	255	51,2	42,5	50,5	51,7	23,5	56,0	40	
6	1,0	50	255	51,2	42,5	50,5	54,4	23,5	56,0	40	
6	1,1	55	280	97,3	25,5	51	52,5	23,5	54,0	40	4 of R 14/UM 2/ Baby/C
6	1,1	55	280	97,3	25,5	51	54,9	23,5	54,0	40	
12	1,1	55	555	97,5	49,5	51	54,9	23,7	55,0	40	8 of R 14/UM 2/ Baby/C
8	1,1	55	385	147,1	26	47	48,5	22,8	50,6	40	6 of
8	1,1	55	400	150	26	52	52,0	22,0	44,4	2	R 14/UM/2/
8	1,1	55	385	147,1	26	47	50,9	22,8	50,6	40	Baby/C
12	1,8	90	835	178,5	34,1	60,5	64,4	25,9	59,5	40	
6	2,0	100	460	75,5	51,1	53,5	57,4	26,1	59,1	60	
2	3,0	150	215	44,0	34,3	60,5	62,1	27,9	65,3	60	
4	3,0	150	410	90,5	34,5	60,5	64,4	29,3	65,4	60	
6	3,0	150	610	134,8	34,8	60,5	62,3	29,5	65,8	60	4 of R 20/UM 1/
6	3,0	150	610	134,8	34,8	60,5	64,4	29,5	65,8	60	Mono/D
12	3,0	150	1230	135,0	70,0	60,5	64,4	29,3	62,9	60	
8	3,0	150	880	178,5	34,1	60,5	64,4	27,3	66,1	60	6 of R 20/UM 1/
8	3,0	150	900	181,5	34	67,5	67,5	26,7	60,6	2	Mono/D
6	3,8	190	850	62,3	50	98	98	26,8	64,3	60	
6	3,8	190	845	62,3	52	98	101,6	27,0	71,8	60	
8	3,8	190	995	85,9	51,8	95	98,9	30,6	65,8	60	
2	5,7	285	358	51	33,5	94,5	96,1	31,8	70,6	80	
6	5,7	285	1095	151,5	34,5	94,5	96,0	31,2	70,8	80	
6	5,7	285	1095	151,5	34,5	94,5	98,4	31,2	70,8	80	
12	5,7	285	2185	151,7	65,5	94,5	98,4	31,3	74,0	80	
12	5,7	285	2226	151,7	65,5	102,5	121,5	30,7	71,9	80	
6	6,5	325	1240	116,5	51	90,5	94,4	31,5	73,9	80	
2	9,5	475	555	52,9	50,5	94,5	98,4	34,2	77,0	80	
6	9,5	475	1675	151,7	50,5	94,5	98,4	34,0	80,2	80	
12	9,5	475	3365	151,5	97,5	94,5	98,4	33,9	82,7	80	
12	12	600	5080	186	81	170,5	170,5	28,3	60,6	200[6]	
12	20	1000	7615	176	167	126,5	126,5	31,5	66,1	100	
12	20	1000	7630	176	167	126,5	130,5	31,5	66,1	200[6]	
12	36	1800	13950	210	175	175	175	31,0	68,2	400[6]	
12	63	3150	23100	381	175	190	190,0	32,7	64,6	440[6]	

Dimensions

For these batteries, the external dimensions of the casings were chosen such that four, six or eight primary cells could be housed in the same volume. If the battery compartment and the mating connectors are suitable designed by the user, these types, as a result of their external dimensions and their voltages, can be interchanged with the quoted primary cells in accordance with DIN 408 66 and IEC Publication 86.

A 208/3,0 N = 6 Mono R 20/UM 1/D

A 206/3,0 U = 4 Mono R 20/UM 1/D

A 208/1,1 N = 6 Baby R 14/UM 2/C

A 206/1,1 U = 4 Baby R 14/UM 2/C

A 212/1,1 S = 8 Baby R 14/UM 2/C

A 200 series
for high cyclic applications

Capacity as a function of load, additional increase of capacity

Figure 9 shows the dependency of the dryfit capacity on the discharge current at $+ 20\,°C$. In the diagram, the capacity of the individual types of battery is quoted as a percentage of the nominal capacity and the load is given as a multiple of the nominal current J_{20} of the battery. The diagram was plotted for an uninterrupted uniform discharge. If pauses are introduced whilst discharging with heavy currents, the battery recuperates and makes it possible to extract a greater capacity.

The bottom edge of the shaded strip gives the percentage of the withdrawable capacity for different loads of a dryfit battery A 200 series after it has been fully charged.

When used in cyclic operation, however, there was an appreciable additional activation of the battery which — particularly in the high current range — led to an increase in capacity. From load cycle to load cycle, therefore, there is an increase of output. The fall in the capacity due to wear which occurs as the age increases is thus more than compensated for over a long period. The latter is also true of operation under voltage limited continuous charging, since the otherwise usual loss of capacity due to age is considerably retarded because of the activation.

The attainable increase of capacity is represented by the upper edge of the shaded strip in Figure 9. However, for very heavy currents and figures in the broken part of the curves, attention must be paid to the maximum permissible load for the particular type of battery as given in the table in Figure 8.

The additional activation in service described above occurs that much more rapidly, the smaller the discharge current
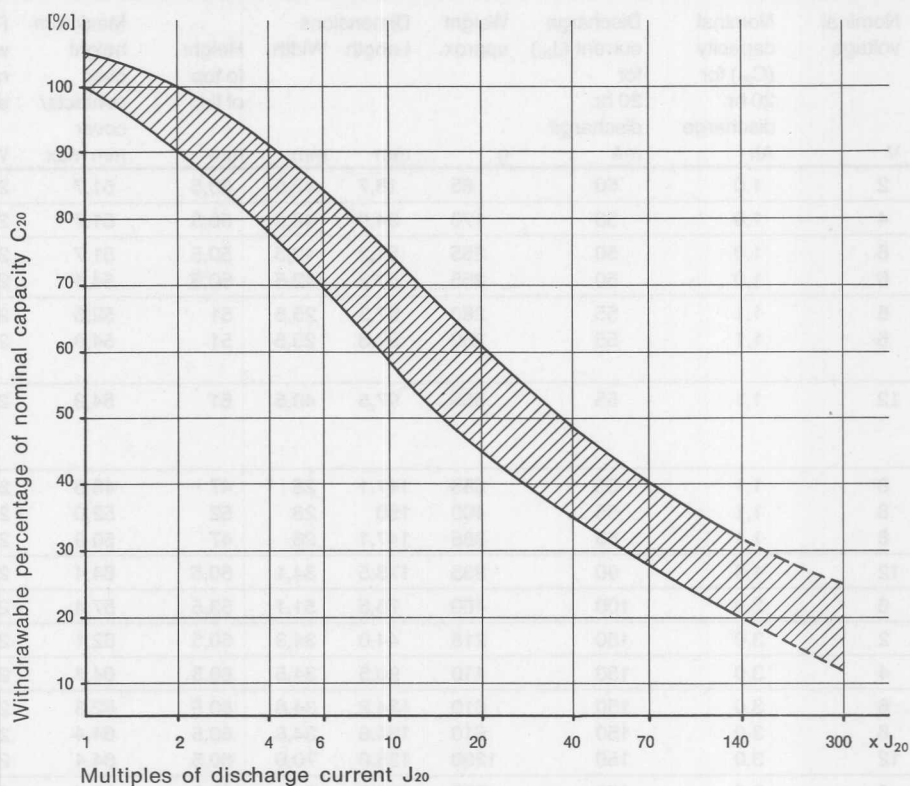

Fig. 9
Capacity as a function of load

and the more complete the discharge during the use of the battery. With a complete discharge at 1 x J_{20}, the maximum capacity is attained after about 25 charging cycles, with a discharge of

Fig. 10
Values for current of individual battery capacities in multiples of J_{20}.

4 x J_{20} after about 50 charging cycles, with a discharge of 20 x J_{20} after about 125 charging cycles and with a heavy current discharge at 40 x J_{20} only after 175 charging cycles. This behaviour shows clearly that the capacity of the dryfit battery for long periods of use moves significantly above the quoted nominal data.

To simplify the evaluation of the curve (Figure 9), the table in Figure 10 quotes the multiples of J_{20} in amperes for the individual battery capacities.

| (Ah)	1 x J_{20} (A)	2 x J_{20} (A)	4 x J_{20} (A)	6 x J_{20} (A)	10 x J_{20} (A)	20 x J_{20} (A)	40 x J_{20} (A)	70 x J_{20} (A)	140 x J_{20} (A)	300 x J_{20} (A)
1,0	0,050	0,100	0,200	0,300	0,500	1,000	2,000	3,500	7,000	15,000
1,1	0,055	0,110	0,220	0,330	0,550	1,100	2,200	3,850	7,700	16,500
1,8	0,090	0,180	0,360	0,540	0,900	1,800	3,600	6,300	12,600	27,000
2,0	0,100	0,200	0,400	0,600	1,000	2,000	4,000	7,000	14,000	30,000
3,0	0,150	0,300	0,600	0,900	1,500	3,000	6,000	10,500	21,000	45,000
3,8	0,190	0,380	0,760	1,140	1,900	3,800	7,600	13,300	26,600	—
5,7	0,285	0,570	1,140	1,710	2,850	5,700	11,400	19,950	39,900	—
6,5	0,325	0,650	1,300	1,950	3,250	6,500	13,000	22,750	45,500	—
9,5	0,475	0,950	1,900	2,850	4,750	9,500	19,000	33,250	66,500	—
12,0	0,600	1,200	2,400	3,600	6,000	12,000	24,000	42,000	84,000	—
20,0	1,000	2,000	4,000	6,000	10,000	20,000	40,000	70,000	—	—
36,0	1,800	3,600	7,200	10,800	18,000	36,000	72,000	126,000	—	—
63,0	3,150	6,300	12,600	18,900	31,500	63,000	126,000	220,500	441,000	—
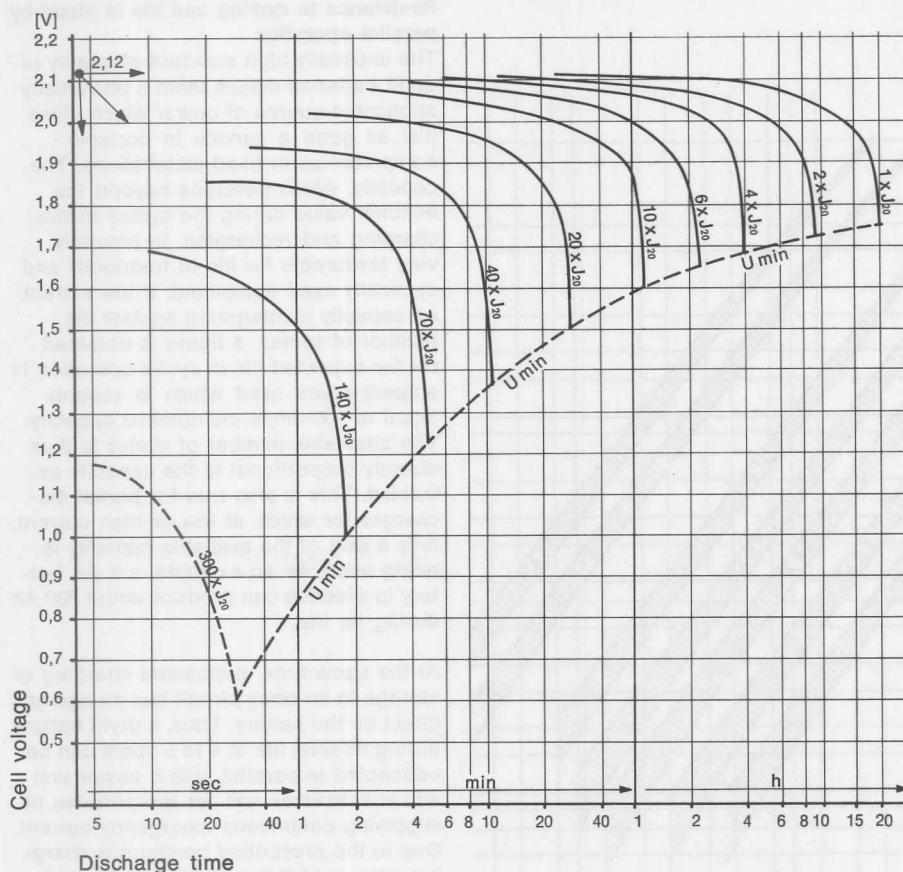
◀ Fig. 11
Discharge time and variation of voltage
V_{min} = minimum normally permissible
end of discharge voltage.

Voltage variation as a function of load
The curves in Figure 11 show, for a range
of loads at + 20 °C, the variation in the
voltage of a single battery during its
discharge with the nominal battery current
J_{20} to 140 or 300 times that figure. From
the no-load voltage of 2.12 V the terminal
voltage of the battery falls more or less
rapidly to the value denoted by the be-
ginning of the individual discharge curves
and then varies in accordance with the
plotted curves. The cross-plotted end
points of these discharge curves produce
the plot of the discharge cut-off voltage
for the particular capacity. If the dis-
charge is continued beyond this cut-off
voltage, the deep discharge region be-
gins.

The curves show yet again the depen-
dency of the discharge time on the parti-
cular load and, indeed, after fully charg-
ing, that is, at the beginning of the period
of use and without the later increase of
output due to activation in service. The
actual values of the discharge current for
the individual capacities can be obtained
from the table in Figure 10.
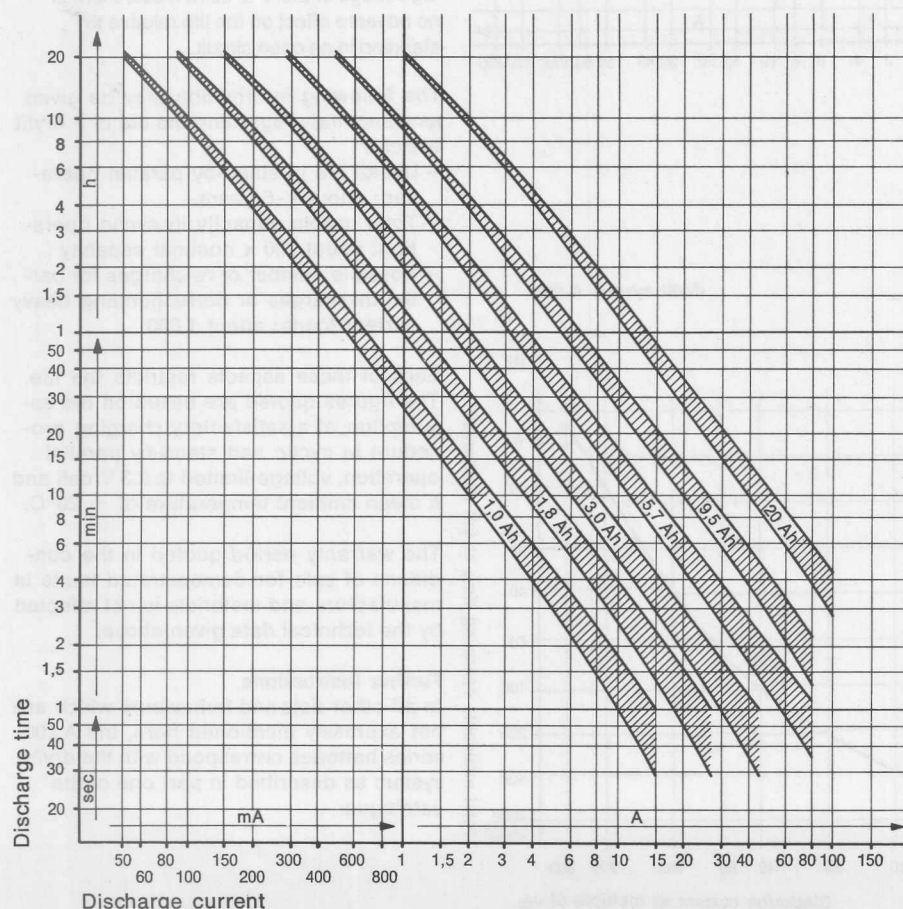
Discharge time as a function of load
The shaded curves in Figures 12 and 13
facilitate the search for a suitable capa-
city for a particular application. Plotted
against a logarithmic scale in milliam-
peres and amperes for the required dis-
charge current, is the attainable conti-
nuous discharge time for an ambient tem-
perature of + 20 °C. This time is also re-
presented on a logarithmic scale in
seconds, minutes and hours. Here, the
lower edge of the band gives the attain-
able discharge time for a new battery of
a particular type, after it has been charg-
ed completely, whilst the upper edge
denotes the attainable extended discharge
time due to increased activation during
use. The quiescent reserve capacity,
which is significant, particularly with
heavy discharge currents, can thus be
read off directly as the reserve discharge
time. For practical reasons the curves for
the available types of battery were shared
between two diagrams as, otherwise, the
curves would overlap.

◀ Fig. 12
Discharge time as a function of the
discharge current.

A 200 series
for high cyclic applications

Fig. 13
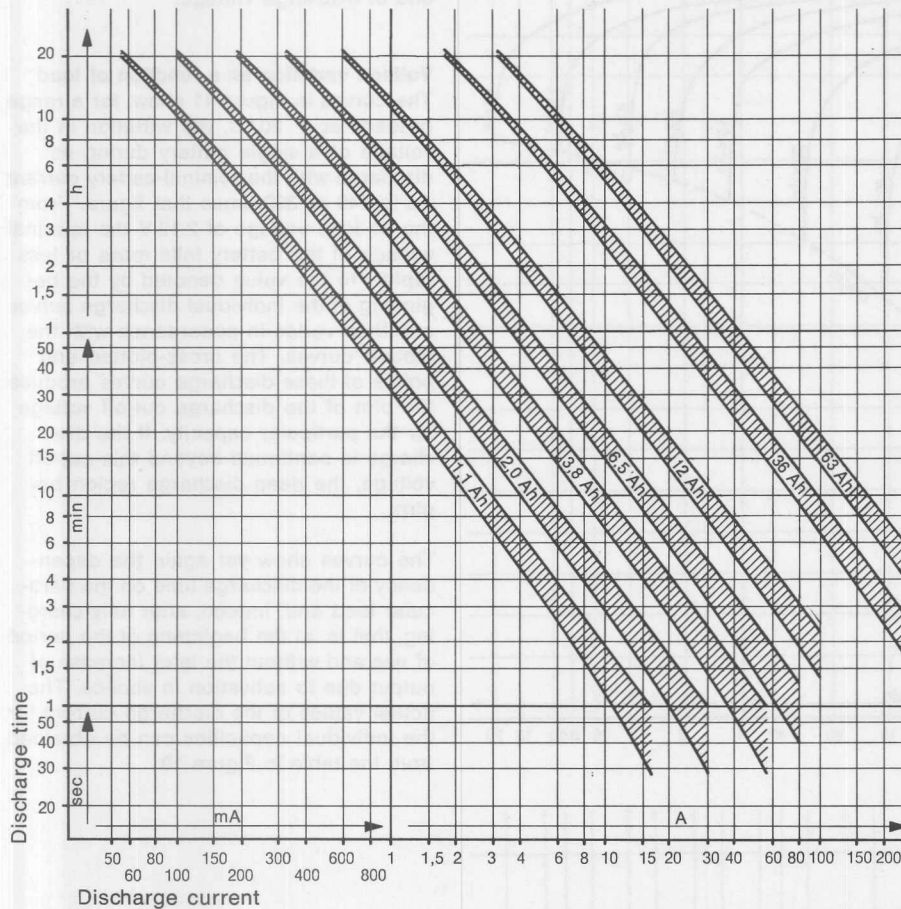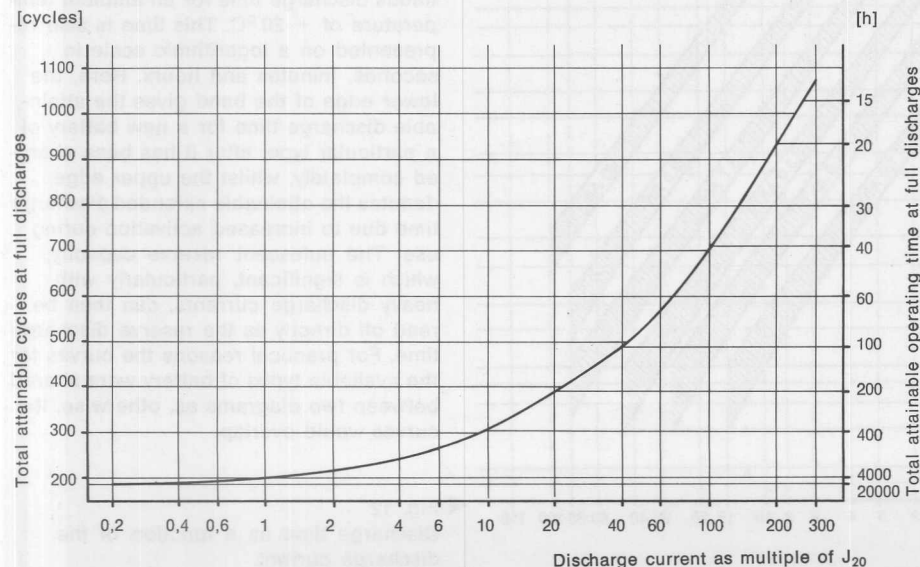Discharge time as a function of discharge current.

Fig. 14
Cyclic stability and accumulated discharge time during life as a function of the discharge current for A 200 series dryfit batteries.

dryfit system A 200

Resistance to cycling and life in stand-by parallel operation

The unusually high standard of quality of dryfit batteries makes them a universally applicable source of power which gives just as good a service in portable equipment as in fixed installations. The capacity, which develops beyond the nominal value during the cycles of discharging and recharging, is naturally very favourable for life in frequently and cyclically used equipment. If the extracted capacity is integrated against the number of cycles, a figure is obtained for the expected life in cyclic operation in ampere-hours used which is roughly equal to 200 times the nominal capacity. The attainable number of cycles is thus directly proportional to the capacity extracted. This is also true for partial discharges for which, at low or high current, only a part of the available capacity is being used. As an example, a 1 Ah battery in practice can produce about 200 Ah during its life.

At the same time, permanent charging or storage in an open circuit has an ageing effect on the battery. Thus, a dryfit battery during its total life of 4 to 5 years can be connected in parallel with a power unit and a consumer unit for the purpose of supplying continuous emergency current. Due to the prescribed continuous charging voltage of 2.3 V $\pm$ 30 mV/cell, there is no adverse effect on the life relative to standing in an open circuit.

The following information may be given as a summary regarding the life of a dryfit battery:
— Useful life in stand-by parallel operation: about 4 - 5 years.
— Total usable capacity in cyclic operation: about 200 x nominal capacity .
— Possible number of re-charges for partial discharges or corresponding heavy current loads: about 1.000.

Each of these aspects restricts the life. The figures quoted are based on the assumption of a satisfactory charging procedure in cyclic and stand-by parallel operation, voltage-limited to 2.3 V/cell and a mean ambient temperature of $+$ 20°C.

The warranty period quoted in the conditions of sale for demonstrated faults in manufacture and materials is not affected by the technical data given above.

Further instructions
In all other data and behaviours which are not expressly mentioned here, the A 200 series batteries correspond with the dryfit-system as described in part one of the catalogue.

A 300 series
for stand-by parallel operation

A 300 series
for stand-by parallel operation

Technical Data
(Right of modification reserved)
In the table in Figure 15, the technical data for the available A 300 series dryfit batteries are listed in tabular form. Particular references will be found in the footnotes.

Type code Type No.[1]	Nominal voltage	Nominal capacity (C_{10}) for 10 hr. discharge	Discharge current (J_{10}) for 10 hr. discharge	Weight approx.	Dimensions Length	Width	Height to top of lid	Maximum height over contacts/ cover	Power/ weight ratio approx.	Power/ volume ratio	Max. load approx. [2]
	Volt	Ah	mA	g	mm	mm	mm	mm max.	Wh/kg	Wh/l	A
07 1 91172 00 A 306/1,0 S	6	1,0	100	255	51,2	42,5	50,5	54,4	23,5	56,0	40
07 1 91182 00 A 306/1,1 S	6	1,1	110	280	97,3	25,5	51	54,9	23,5	54,0	40
07 1 91185 00 A 312/1,1 S	12	1,1	110	555	97,5	49,5	51	54,9	23,7	55,0	40
07 1 91202 00 A 312/1,8 S	12	1,8	180	835	178,5	34,1	60,6	64,4	25,9	55,0	40
07 1 91262 00 A 306/2,0 S	6	2,0	200	460	75,5	51,5	53,5	57,4	26,1	59,1	60
07 1 91280 00 A 302/3,0 V	2	3,0	300	215	44,9	34,3	60,5	62,1	27,9	65,3	60
07 1 91302 00 A 304/3,0 S	4	3,0	300	410	90,5	34,5	60,5	64,4	29,3	65,4	60
07 1 91312 00 A 306/3,0 S	6	3,0	300	610	134,8	34,8	60,5	64,4	29,5	65,8	60
07 1 91421 00 A 302/5,7 V	2	5,7	570	358	51	33,5	94,5	96,1	31,8	70,6	80
07 1 91432 00 A 312/5,7 S	12	5,7	570	2185	151,7	65,5	94,5	98,4	31,3	74,0	80
07 1 91472 00 A 306/6,5 S	6	6,5	650	555	116,5	51	90,5	94,4	34,2	73,9	80
07 1 91502 00 A 302/9,5 S	2	9,5	950	1240	52,9	50,5	94,5	98,4	31,5	77,0	80
07 1 91523 00 A 306/9,5 S	6	9,5	950	1675	151,7	50,5	94,5	98,4	34,0	80,2	80
07 1 91525 00 A 312/9,5 S	12	9,5	950	3365	151,5	97,5	94,5	98,4	33,9	82,7	80

Fig. 15
A 300 series dryfit batteries, range of products and technical data.

1. The last letter of the type code indicates the type of terminals, as shown in Figure 2.

2. Only with suitable mating contacts. See the section on "Load capacity" in the text.

A 300 series
for stand-by parallel operation

Capacity as a function of load

Figure 16 shows the dependency of the dryfit capacity on the discharge current at + 20 °C. In the diagram, the capacity of the individual battery types is quoted as a percentage of the nominal capacity and the load is given as a multiple of the nominal current J_{10} of the battery. The diagram was plotted for an uninterrupted uniform discharge. If pauses are introduced whilst discharging with heavy currents, the battery recuperates and makes it possible to extract a greater capacity.

To simplify the evaluation of the curve (Figure 16), the table in Figure 17 quotes the multiples of J_{10} in amperes for the individual battery types.

Fig. 17
Values for current of individual battery types in multiples of J_{10}.

Ah	1 x J_{10} (A)	2 x J_{10} (A)	3 x J_{10} (A)	5 x J_{10} (A)
1,0	0,10	0,20	0,30	0,50
1,1	0,11	0,22	0,33	0,55
2,0	0,20	0,40	0,60	1,00
3,0	0,30	0,60	0,90	1,50
5,7	0,57	1,14	1,71	2,85
6,5	0,65	1,30	1,95	3,25
9,5	0,95	1,90	2,85	4,75

Ah	20 x J_{10} (A)	35 x J_{10} (A)	70 x J_{10} (A)	150 x J_{10} (A)
1,0	2,00	3,50	7,00	15,00
1,1	2,20	3,85	7,70	16,50
2,0	4,00	7,00	14,00	30,00
3,0	6,00	10,60	21,00	45,00
5,7	11,40	19,85	39,90	85,50
6,5	13,00	22,75	45,50	97,50
9,5	19,00	33,25	66,50	142,50

▲ Multiples of discharge current J_{10}

Fig. 16
Capacity as a function of load

Discharge time as a function of load

The shaded curves in Figure 18 facilitate the search for a suitable capacity for a particular application. Plotted against a logarithmic scale in milliamperes and amperes for the required discharge current is the attainable continuous discharge time for an ambient temperature of + 20 °C. This time is also represented on a logarithmic scale in seconds, minutes and hours.
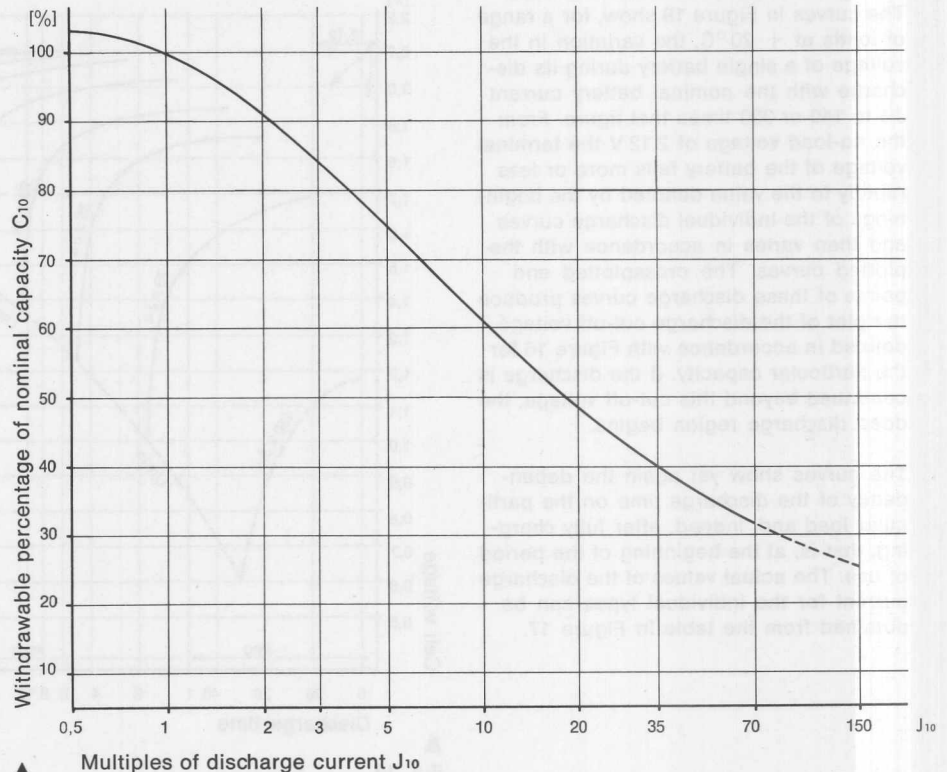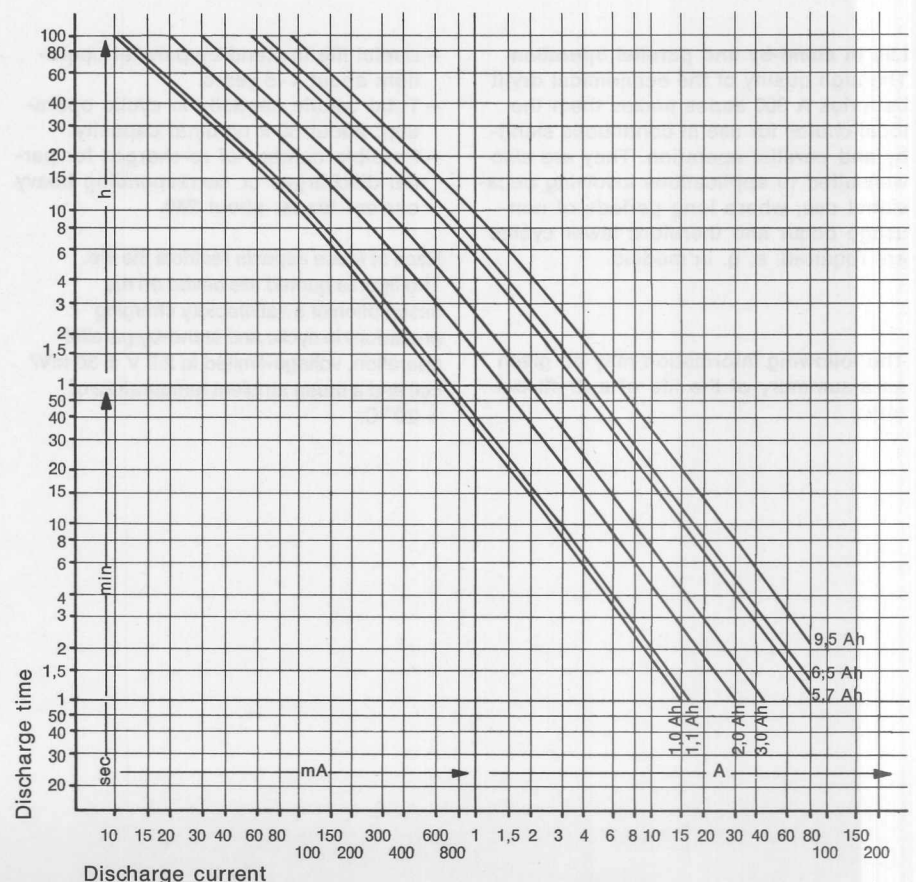
Fig. 18 ▶
Discharge current, discharge times

Discharge current

Voltage variation as a function of load

The curves in Figure 19 show, for a range of loads at + 20 °C, the variation in the voltage of a single battery during its discharge with the nominal battery current J_{10} to 140 or 300 times that figure. From the no-load voltage of 2.12 V the terminal voltage of the battery falls more or less rapidly to the value denoted by the beginnings of the individual discharge curves and then varies in accordance with the plotted curves. The crossplotted end points of these discharge curves produce the plot of the discharge cut-off voltage defined in accordance with Figure 16 for the particular capacity. If the discharge is continued beyond this cut-off voltage, the deep discharge region begins.

The curves show yet again the dependency of the discharge time on the particular load and, indeed, after fully charging, that is, at the beginning of the period of use. The actual values of the discharge current for the individual types can be obtained from the table in Figure 17.
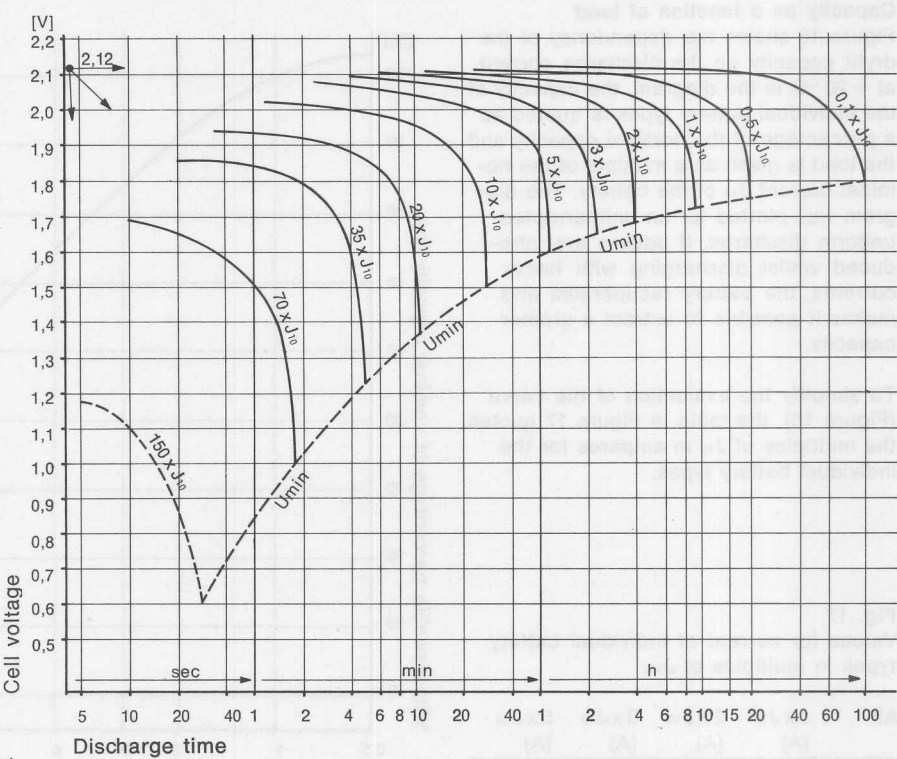
▲
Fig. 19
Voltage variations during discharge

Life in stand-by and parallel operation

The high quality of the economical dryfit batteries A 300 series makes them the ideal choice for use in continuous stand-by and parallel operation. They are also wellsuited to applications involving occasional use, where long periods of non-usage occur and therefore fewer cycles are required, e. g. in models.

The following information may be given as a summary of the life of a dryfit battery:

— Useful life in stand-by parallel operation: about 4 - 5 years.
— Total usable capacity in cyclic operation: about 60 x nominal capacity.
— Possible number of re-charges for partial discharges or corresponding heavy current loads: about 240.

Each of these aspects restricts the life. The figures quoted are based on the assumption of a satisfactory charging procedure in cyclic and stand-by parallel operation, voltage-limited to 2.3 V ± 30 mV/cell and a mean ambient temperature of + 20 °C.

The warranty period quoted in the conditions of sale for demonstrated faults in manufacture and materials is not affected by the technical data given above.

Further instructions:
In all other data and behaviours which are not expressly mentioned here, the A 300 series batteries correspond with the dryfit-system as described in part one of the catalogue.

Charging technique 4
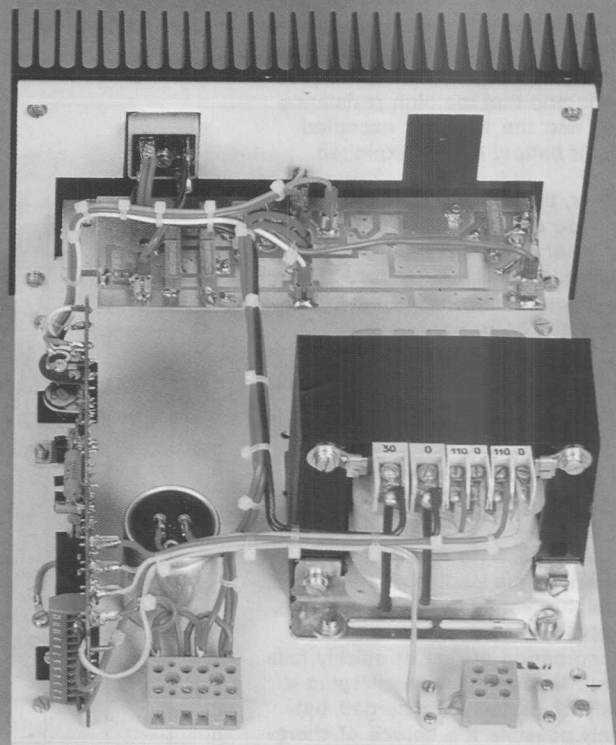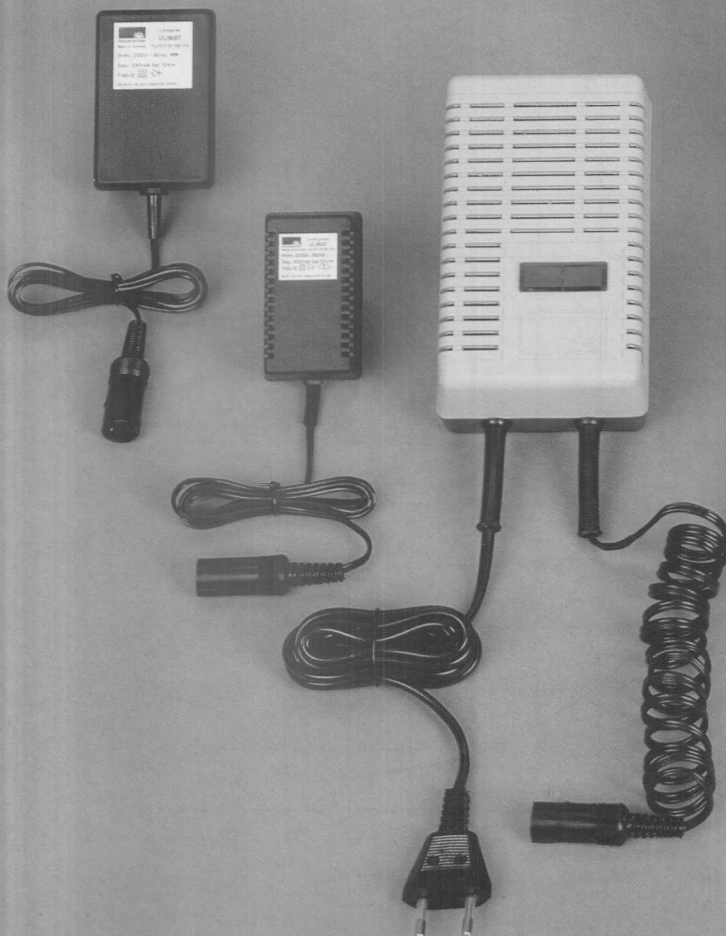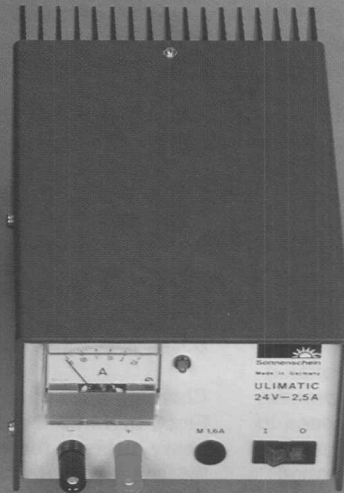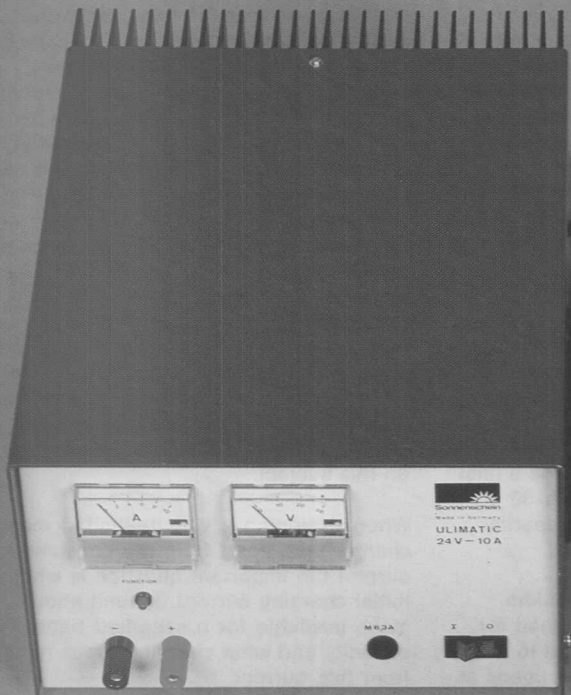
Charging technique

Uncontrolled chargers

These chargers operate with uncontrolled, falling current characteristics, determined by the cell voltage which increases as the charge builds up. The drop in the charging current becomes larger the nearer the charging voltage and the permissible final charging voltage become, and the smaller the internal resistance of the charging current source. The greatest disadvantage of the uncontrolled simple charger, consisting basically of only a transformer and a rectifier, is the very strong dependence of the final charging voltage on the input a. c. voltage and the associated danger of detrimental overcharging.

Automatic voltage-limited charging

Dryfit batteries have the property of considerably altering the voltage and current consumption during the charging process in accordance with the charge state reached at the time. This makes it possible to control the charging process electronically at all stages and hence to allow it to proceed fully automatically, that is without any attention or intervention from the user, completely independently of whether the battery was previously fully discharged or only partially discharged. In addition to this complete freedom from attention, the fully automatic running of the charging process ensures that there is no overcharging and consequential damage and that the high resistance to cycling and the long life expected from a dryfit battery is fully exploited.

For the user, the fact that he can exploit fully the good characteristics of the battery may be of the same importance as complete freedom from attention. The charging procedure, as described below, guarantees him both.

Off-load voltage, final charging voltage

The fully charged dryfit battery produces, in open circuit, an off-load voltage of between 2.12 and 2.15 V/cell which is slightly dependent on the ambient temperature. Until a day after the end of the charging process, as a result of a possible remaining gas loading on the plates, an even higher voltage value is possible, but this approaches the quoted value after a long period of rest or quickly falls under load. Naturally, fully recharging a completely or partially discharged battery is only possible if a source of charging voltage above the off-load voltage is connected to the battery and it pushes a charging current into the battery dependent on the magnitude of the voltage difference and the internal resistance of the circuit.

The special properties of the dryfit battery permit — at a mean ambient temperature of + 20 °C — a charging voltage which is always greater than the off-load voltage but which produces no overcharging and hence no damage due to loss of water and corrosion. The current of about 1 mA/Ah of nominal capacity which still flows after the battery is fully charged, due to the difference between the off-load voltage of the battery and the charging voltage source, has no adverse effect on the life of the battery but covers all the losses, even those on older batteries due to increased self-discharge.

For ambient temperatures permanently outside the normal temperature range of + 20 °C, it is advisable to match the final charging voltage to the curve in Figure 6. If the temperature only varies by the hour this is not necessary. For the normal temperature range a final charging voltage of 2.3 V/cell $\pm$ 30 mV tolerance inclusive possible superimposed a. c. ripple is best.
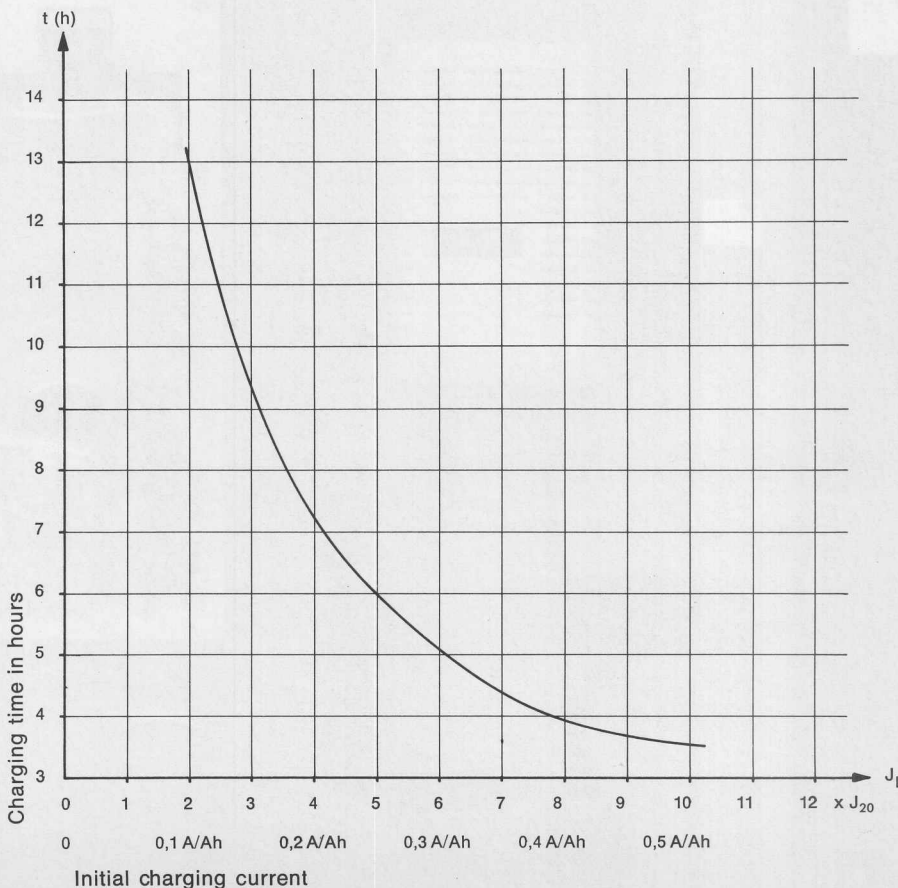
Charging current and charging time

Since dryfit batteries are designed for heavy currents there is no need to limit the charging current. Attention needs to be given only to the voltage limit of the charger which must be set at 2.3 V x the number of cells. This limiting value for the final charging voltage applies only to a mean ambient temperature of + 20 °C.

If charging commences at 2.3 V/cell on a dryfit battery which is fully discharged according to the nominal capacity, peak currents of about 3 A/Ah of nominal capacity flow during the first few seconds but they soon stabilize and remain for a long time at about 0.5 A/Ah. The initial charging current set up under these voltages is very dependent on the state of charge as well as on the size of the battery. So the initial charging current for a dryfit battery discharged far beyond its nominal capacity may be in the milli-ampere range at the start of charging because of the increased internal resistance, and may only increase to the full value after the breakdown of the internal resistance. Unfortunately it is not possible to give more accurate information on this subject.

When designing a voltage-limited mains/charger unit, apart from the consumer current the important question is what initial charging current the unit should make available for a specified battery capacity and what charging times result from this current.

Fig. 22
Charging time as a function of the initial charging current up to 90 % of the fully charged state.

Charging technique

Figure 22 shows the charging time in hours to 90 % of full charge, plotted against the initial charging current expressed in multiples of the 20 hour current or in A/Ah of nominal capacity. It is based on a battery which is completely discharged at the 20 hour discharge rate according to the nominal capacity but which is not deep discharged. The initial charging current of about 0.5 A/Ah of nominal capacity rapidly diminishes due to the voltage limiting of the charger with increasing counter-voltage. It continues to drop, until the end of the charging operation, to a small continuous current which can be tolerated by the battery for a long time. For example, for an initial charging current of $2 \times J_{20}$, a charging time of 13.25 hours is required for 90 % of full charge. To complete the same charging process in 4 hours, an initial charging current of $8 \times J_{20}$ is required, corresponding to 0.4 A/Ah of nominal capacity. Since the internal resistances of the dryfit batteries are different and there are certain differences in the charging efficiency between new and older batteries, a tolerance $\pm$ 20 % must be applied to the graph in Figure 22.

The charging time, as is well known, is also largely dependent on the past history of the battery. A battery discharged with a very heavy current accepts immediately afterwards a very heavy charging current and this makes possible extremely short charging times. But if several hours elapse between the end of the discharge and the beginning of the charging process, the core of the battery plates discharges to the benefit of the surface of the plates and the charging current consumption returns to the normal value of about 0.5 A/Ah of nominal capacity.

Cyclic operation
By cyclic operation is understood a method of operation by which the battery is continually charged and discharged. Thus the battery is normally only connected to the charger for as long as is necessary for the charging process.

Unregulated chargers can only be used for cyclic operation of dryfit batteries if they make use of a higher output voltage which is limited again by a series resistance, to guarantee the greatest possible independence of the charging current from variations in mains voltage and from increases of the battery voltage during the charging process and if there are clear, empirically derived instructions regarding the charging times as a function of the charging current and the charging state at the beginning of the charging process and these instructions are complied with.

However, the charging current must at no time exceed $2 \times J_{20}$. In practice, when charging dryfit batteries with unregulated chargers some adverse effect on the life can be detected, since experience shows that the prescribed charging time is only maintained very approximately. The high resistance of the dryfit battery to cycling can only be fully exploited if the permissible final charging voltage of 2.3 V/cell at + 20 °C is not exceeded or if the value in Figure 6 is adhered to, which takes account of the dependence on the temperature. If, in cyclic operation, importance is attached to particularly good current consumption and the associated short charging time, a final voltage of 2.35 V/cell is still permissible at normal temperature if the application and the operating instructions ensure that the battery never remains connected to the charger for longer than a week.

Continuous stand-by/parallel operation
This definition describes a type of operation in which the battery is continually subjected to a charging voltage and is only fully or partially discharged a few times during its whole useful life. In stand-by/parallel operation, the consumer unit is also connected in parallel to the mains unit and the battery. It must be ensured that the mains power unit is at all times capable of supplying the current required by the load, including any peaks, without the output voltage of the unit falling below the off-load voltage of the battery of 2.15 V/cell. Only if the mains supply fails does the battery take over the powering of the load. With this type of operation and properly adjusted power and charger units, no adjustment is required. The charging process and the maintenance of the charge are produced completely automatically.

Since the battery is connected to the charging voltage during the whole of its life, the value of 2.3 V/cell must never be exceeded. A positive tolerance of 30 mV/cell should not be exceeded, including superimposed a. c. voltages, for example in thyristor circuits.

Since, for stand-by parallel operation, use is normally only made of batteries whose capacity is not too restricted and mains failures in industrial areas usually last only a short time, the bottom tolerance on the charging voltage can be lower. There need be no reservations about a minimum value of 2.25 V/cell — that is, 100 mV above the off-load voltage.

Charging by motor vehicle generator
12 V batteries can be wired up via a Silicon diode with a load capacity of min. 0.8 A/Ah battery capacity in the car. This diode prevents a discharge of the dryfit battery when starting the motor vehicle and reduces the charging voltage of the generator to suitable values for the battery.

Continuous float operation
In float operation too, the power unit battery and load are permanently connected together. Thus the same requirements are applicable to the final charging voltage as for stand-by parallel operation. The types of operation differ only in that the power unit has to produce the average currents required by the consumer and its output voltage falls below the off-load voltage of the parallel connected battery during short period load peaks. Part of the peak current to the load must, therefore, be provided by the battery. Care must be taken to ensure that the time between the peaks is sufficient for the battery to recharge fully, since otherwise a progressive discharge of the battery would take place.

In order to ensure a satisfactory useful life, it is necessary to know when the battery is selected how many ampere-hours in excess of the capacity of the power unit it has to provide to the load per unit of time. If necessary, a larger dryfit battery must be used since, with frequent large peak loads, it is possible after only a relatively short time to extract the 200 times nominal capacity of A 200 series or 60 times nominal capacity of A 300 series batteries, which is anticipated as the average life.

For example: The following are connected in parallel: a power unit with inductive output voltage regulation on the primary side to an arithmetical output voltage of 2.3 V/cell, a battery with a 20 Ah capacity and a consumer unit with a steady current of 15 A. At each alternation of the mains power, that is 100 times a second, the output potential at the bridge rectifier used on the secondary side of the power unit goes to zero. From a graph of the relationships it can be seen that the current consumed is actually supplied over a phase angle of 62 °/half wave by the battery and only over a phase angle of 28 °/half wave by the power unit. Only during this time is the potential of the rectifier higher than the off-load voltage of the battery. Hence the battery is, strictly speaking, discharged during $2/3$ of the total time or — to put it another way — on average 10 A of the 15 A of load current is continually produced by the battery. During the time that the effective half waves are flowing, the time is too short to recharge the capacity extracted in between. This average discharge of 10 A extracts from the 20 Ah battery 4000 Ah in only 17 days, that is 200 times the nominal capacity and it exhausts the cycling capability of the battery. This very extreme example indicates the necessity of accurate planning of the charger/power supply system, since this type of operation puts a very severe load on a battery. In any case, stand-by parallel operation is better.

Charging technique

Series and parallel circuits

Naturally, the only batteries which can be charged in series are those having the same nominal capacity, exactly the same state of charge and the same age and which have, therefore, been discharged in series too. They only guarantee uniform voltage distribution during the charging process. The number of battery cells which can be connected in series must be limited to a maximum of 12 cells, giving a 24 V battery, unless special circuitry is employed, otherwise adverse effects on life must be reckoned with. For nominal voltages above 12 V it is not necessary, but advisable, for nominal voltages above 24 V however absolutely essential, to subdivide the charging circuit into a number of loops so that a uniform distribution of the charging voltage between the individual batteries is ensured. The slightest difference between the individual cells in high voltage series circuits produces a rapid overcharging of the cells with a small capacity which, in the long term, leads to failure of the whole battery.

The life is favourably affected if a voltage divider consisting of resistors with an accuracy of 1 % is connected in parallel with the battery and a current of 5 mA, or better still 10 mA per ampere-hour of nominal battery capacity is flowing through it. An interconnecting circuit (See Figure 23) should be introduced at as many points as possible between the voltage divider and the battery. Since, after charging is completed — that is during the greatest part of the life of the battery — under the applied voltage of 2.3 V/cell a current of the order of 1 mA/Ah of nominal capacity is flowing, the 5 to 10 times higher transverse current in the voltage divider has a powerful stabilizing effect on the cell voltage.

If it should happen that the battery, voltage divider and power unit have to stand for a long time without being connected to the power supply, a mains voltage dependent relay is introduced which disconnects the voltage divider resistors and thus prevents discharge of the battery.

For high capacity batteries — for example, in series parallel circuits — high-power resistors must be used so that, instead of the individual resistors, a circuit like the one in Figure 24 produces very good results. As the terminal voltage at the end of the charging procedure increases from 2.33 to 2.35 V/cell, that is from 13.98 V to 14.1 V for the 12 V battery, the stabilizing transverse current suddenly increases from practically 0 to 500 mA and this produces a very good stabilizing effect.

Basically it is advisable as far as possible to positively prevent deep discharging of high-voltage batteries.

The discharge current of the cells with the largest capacities — and there are always small variations of capacity — acts on the already completely discharged cells in the series circuit like a charging current of the wrong polarity.

When charging batteries of the same nominal voltage, there are no objections at all to a parallel circuit of any number of items. But care must be taken that no uncontrolled voltage drops occur over the charging cable. It is advisable, therefore, to install the positive connections to these batteries in the reverse order to the negative connections so as to produce equalisation of potential between the parallel connected batteries. For a higher voltage parallel circuit it is also worthwhile introducing, at intervals of about 12 V, from battery to battery, cross-connections which ensure uniform distribution of the charging voltage (See Fig. 23).
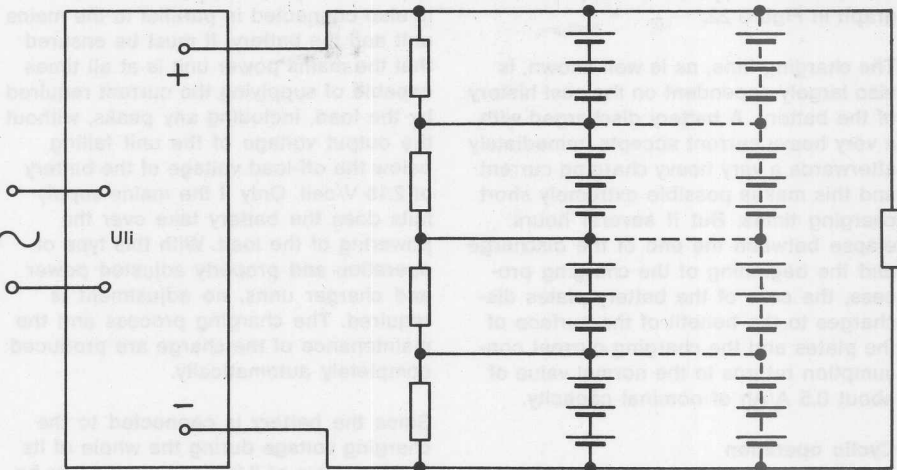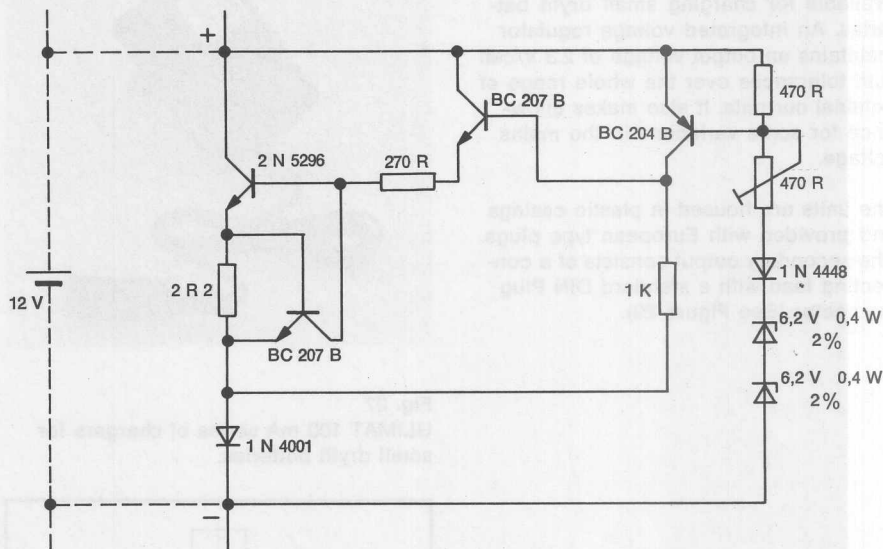

Fig. 23
Interconnected series and parallel circuit with distribution of the charging voltage.
Uli = voltage-limited power unit.

Charging technique

Fig. 24
Active parallel circuit for voltage distribution.

Fig. 25
Simple voltage-limited charging circuit.

Typical circuits

There is extensive literature dealing with the design of power supply units which have constant output voltage or are limited to their maximum value, so that any detailed explanation can be dispensed with here. For some time, integrated circuits have been used more and more in voltage controlled power units. Here, however, it is the intention to put forward a few proposed circuits which, at reasonable outlay, have proved themselves to be suitable as charging circuits for dryfit batteries.

The simplest basic circuit is shown in Figure 25. Apart from the mains transformer and the bridge rectifier, it includes only a series transistor T, controlled by a Zener diode Z with a balancing resistor R_a, with its base resistor R_b. The Zener diode D should, if possible, have a tolerance of only 1 %. With the aid of the balancing resistor, it is aligned to 2.3 V times the number of cells to be charged so that the voltage limiting is effected by way of the series transistor was selected with sufficiently high current amplification and the unit was designed for battery voltages for which Zener diodes with low dynamic internal resistance exist, the tolerances on the output voltage, which are dependent on the charging current and the mains voltage, can be maintained within reasonably acceptable limits for batteries requiring to be charged in cyclic operation.

When selecting the size of the series transistor T, care must be taken to allow for the fact that, if there is a short circuit, the whole of the power output of the charger is dissipated in the series transistor. It is, therefore, essential to provide the necessary heat sink. The table in Figure 26 lists the possible circuit components for several battery voltages.

Fig. 26
Component list for simple 300 mA charger.
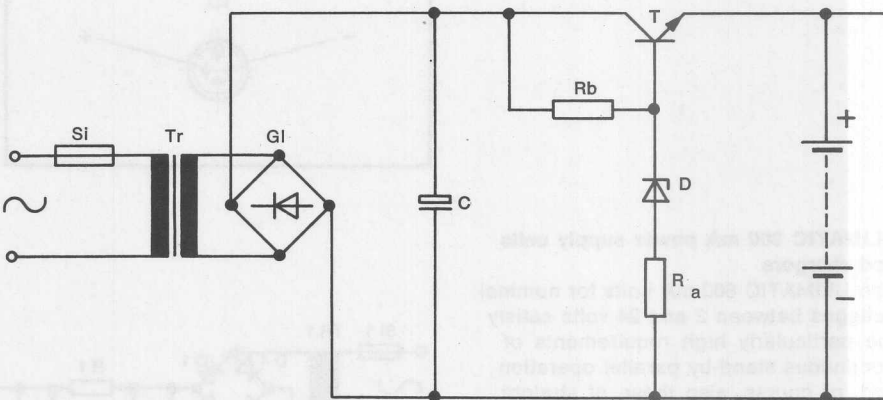
		300 mA	300 mA	300 mA	300 mA
Nominal current		300 mA	300 mA	300 mA	300 mA
Nominal voltage		4 V	6 V	8 V	12 V
Voltage limit		4,6 ± 0,1 V	6,9 ± 0,15 V	9,2 ± 0,2 V	13,8 ± 0,3 V
Transformer, sec. 500 mA	Tr	6,5 ... 6,8 V	8 ... 8,3 V	9,5 ... 9,8 V	12,5 ... 13 V
Rectifier	Gl	B 30 C 600	B 30 C 600	B 30 C 600	B 30 C 600
Electrolytic capacitor	C	470 µF/25 V	470 µF/25 V	470 µF/25 V	470 µF/25 V
Transistor	T	2 N 5296 or similar	2 N 5296 or similar	2 N 5296 or similar	2 N 5296 or similar
Zener diode, 400 mA, ± 2%	D	5,1 V	7,4 V	9,7 V	14,3 V
Base resistor	R_b	270 R 0,5 W	270 R 0,5 W	270 R 0,5 W	270 R 0,5 W
Balancing resistor	R_a	max. 10 R 5 %	max. 10 R 5 %	max. 10 R 5 %	max. 10 R 5 %
Anti surge fuse	Si	0,05 A	0,05 A	0,05 A	0,1 A

Charging technique

ULIMAT and ULIMATIC chargers and power supply units. Range of units available.

ULIMAT 100 mA and 250 mA chargers

The ULIMAT 100 mA (Figure 27) and ULIMAT 250 mA (Figure 28) chargers are available for charging small dryfit batteries. An integrated voltage regulator maintains an output voltage of 2.3 V/cell with tolerances over the whole range of nominal currents. It also makes allowance for some variations in the mains voltage.

The units are housed in plastic casings and provided with European type plugs. The secondary output consists of a connecting lead with a standard DIN Plug connector (See Figure 29).
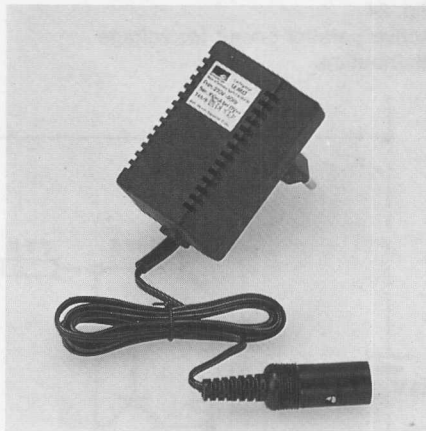

Fig. 27
ULIMAT 100 mA series of chargers for small dryfit batteries.

Fig. 28
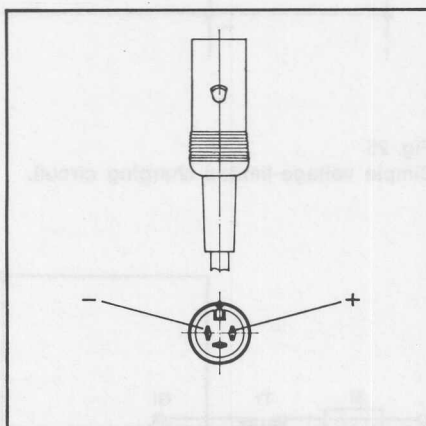ULIMAT 250 mA series of chargers for small dryfit batteries.

Fig. 29
3 pin DIN plug. Secondary connection for the ULIMAT 100 mA and 250 mA chargers and the ULIMATIC 250 mA power supply and charger unit.

ULIMATIC 800 mA power supply units and chargers

The ULIMATIC 800 mA units for nominal voltages between 2 and 24 volts satisfy the particularly high requirements of continuous stand-by parallel operation and, of course, also those of straight forward charging applications. The complete circuit diagram is shown in Figure 30. It shows the electrical functioning of this range of units in detail, including the prevention of damage due to short circuiting and overload, and the precautions against reversed connection of the battery. The regulation of the output voltage is improved by the compensation of the internal resistance of the unit which has a favourable effect on the stability of the output voltage. A lamp shows that the charging process has been properly initiated. It only goes out when the current has fallen to a negligibly small value. With the charger connected but no supply voltage, it should be noted that a small discharge current of a few mA flows through the voltage divider at the output of the unit.
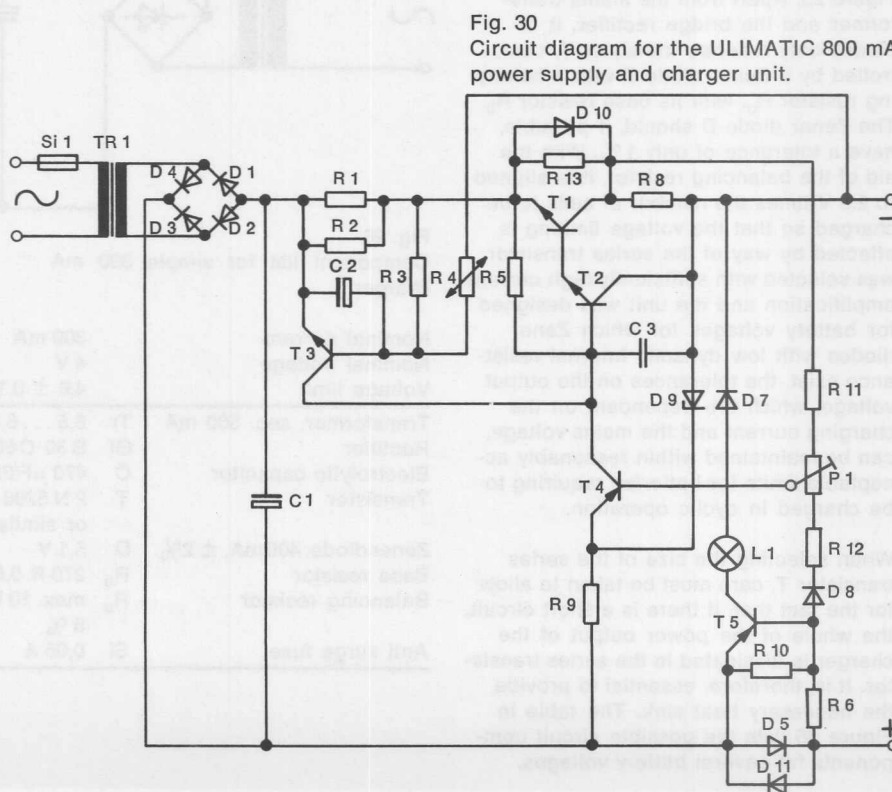
Fig. 30
Circuit diagram for the ULIMATIC 800 mA power supply and charger unit.

Charging technique

ULIMATIC 2.5 A, 5 A and 10 A chargers and power supply units

The ULIMATIC chargers and power supply units in the 2.5 A, 5 A and 10 A range (See Figure 21) satisfy the most stringent demands as fixed voltage supply units for continuous powering of very sensitive consumer units and for any other battery operation. Naturally, they can also be used as power supply units. The electronics chassis including the transformer, printed circuit board and heat sink together with the power transistor is attached by 4 screws and can easily be removed after removing the cover and disconnecting the electrical connection to the front panel.

The units in this outstanding series are voltage-limited, current-limited, protected against reserved polarity, continuous overload and continuous short-circuiting. The mains voltage can be switched to 110 or 220 volts. Functional monitoring is provided by an ammeter and a light emitting diode which indicates charging currents to less than 300 microamperes by means of an amplifier.

The output voltage is fed to silvered terminals which can be loaded to 15 A. The back containing the entrance for the mains cable consists of a finned heat sink. The units are all insulated and satisfy the relevant standards.

As Figure 21 shows, the units in this series can be delivered for incorporation in large static installations without the casing, meters and controls. The table in Figure 32 gives detailed information regarding all other technical data and characteristics.

Fig. 31
ULIMAT, ULIMATIC

1. Production to be discontinued.

2. Version the same as the units tested by DEMKO, SEMKO and NEMKO.

3. without housing.

4. Version the same as the 2.5 A units tested by the VDE.

D = DEMKO
S = SEMKO
N = NEMKO

Type No.	Type name Battery nominal voltage Initial charging current	Mains voltage	Approvals
12 0 97160 00	ULIMAT 4 V/100 mA[1]	220	
12 0 97161 00	ULIMAT 6 V/100 mA[1]	220	
12 0 97162 00	ULIMAT 8 V/100 mA[1]	220	
12 0 97163 00	ULIMAT 12 V/100 mA[1]	220	
12 0 97165 00	ULIMAT 4 V/250 mA[1]	220	
12 0 97166 00	ULIMAT 6 V/250 mA[1]	220	
12 0 97167 00	ULIMAT 8 V/250 mA[1]	220	
12 0 97168 00	ULIMAT 12 V/250 mA[1]	220	
12 0 97740 00	ULIMATIC 2 V/800 mA	220	VDE, SEV
12 0 97750 00	ULIMATIC 4 V/800 mA	220	VDE, SEV
12 0 97760 00	ULIMATIC 6 V/800 mA	220	VDE, SEV
12 0 97775 00	ULIMATIC 8 V/800 mA	220	VDE, SEV
12 0 97795 00	ULIMATIC 12 V/800 mA	220	VDE, SEV
12 0 97810 00	ULIMATIC 18 V/800 mA	220	VDE, SEV
12 0 97820 00	ULIMATIC 24 V/800 mA	220	VDE, SEV
12 0 97344 00	ULIMATIC 12 V/800 mA[3]	220	
12 0 97798 00	ULIMATIC 12 V/800 mA	220	
12 0 97945 00	ULIMATIC 2 V/800 mA	110/220	SEV[2]
12 0 97946 00	ULIMATIC 4 V/800 mA	110/220	SEV[2]
12 0 97947 00	ULIMATIC 6 V/800 mA	110/220	SEV, D[2]
12 0 97948 00	ULIMATIC 8 V/800 mA	110/220	SEV[2]
12 0 97949 00	ULIMATIC 12 V/800 mA	110/220	SEV, S, D, N
12 0 97950 00	ULIMATIC 18 V/800 mA	110/220	SEV[2]
12 0 97951 00	ULIMATIC 24 V/800 mA	110/220	SEV, D[2]
12 0 97953 00	ULIMATIC 6 V/2,5 A	110/220	VDE, SEV
12 0 97954 00	ULIMATIC 12 V/2,5 A	110/220	VDE, SEV
12 0 97955 00	ULIMATIC 24 V/2,5 A	110/220	VDE, SEV
12 0 97150 00	ULIMATIC 6 V/2,5 A[3]	110/220	
12 0 97151 00	ULIMATIC 12 V/2,5 A[3]	110/220	
12 0 97152 00	ULIMATIC 24 V/2,5 A[3]	110/220	
12 0 97956 00	ULIMATIC 6 V/5 A[4]	110/220	SEV
12 0 97957 00	ULIMATIC 12 V/5 A[4]	110/220	SEV
12 0 97958 00	ULIMATIC 24 V/5 A[4]	110/220	SEV
12 0 97153 00	ULIMATIC 6 V/5 A[3]	110/220	
12 0 97154 00	ULIMATIC 12 V/5 A[3]	110/220	
12 0 97155 00	ULIMATIC 24 V/5 A[3]	110/220	
12 0 97959 00	ULIMATIC 6 V/10 A[4]	110/220	SEV
12 0 97960 00	ULIMATIC 12 V/10 A[4]	110/220	SEV
12 0 97961 00	ULIMATIC 24 V/10 A[4]	110/220	SEV
12 0 97156 00	ULIMATIC 6 V/10 A[3]	110/220	
12 0 97157 00	ULIMATIC 12 V/10 A[3]	110/220	
12 0 97158 00	ULIMATIC 24 V/10 A[3]	110/220	
12 0 97970 00	Charging-adapter 6 V/0.5 A		
12 0 97909 00	Charging-adapter 8 V/0.5 A		
12 0 97701 00	Carry case for ULIMATIC 800 mA, Skai		

For complete power supply in 19″ racks equipped with dryfit batteries, combined mains-operated power supply and charger, inverter, and converter please see detailed catalog "dryfit compact".

Charging technique

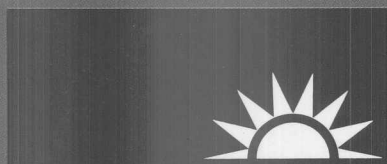| Type	ULIMAT 100 mA	ULIMAT 250 mA
Dimensions of unit (W x H x L)	41.5 x 37 x 72.5 mm without plug	52.5 x 39 x 83.5 mm without plug
Weights	250 g approx.	350 g approx.
Max. dimensions of unit without casing (W x H x L)	—	—
Weights without casing	—	—
Casing material	Noryl	ABS
Paint and colour	Black	Black
Mains voltage	220 V ± 10 % 50/60 Hz	220 V ± 10 % 50/60Hz
Controls	—	—
Voltmeter	—	—
Output current at nominal mains voltage − 15 % [3]	Greater than 50 mA at 2 V/cell	Greater than 125 mA at 2 V/cell
Output current at nominal mains voltage − 10 % [3]	Greater than 70 mA at 2 V/cell	Greater than 175 mA at 2 V/cell
Output current at nominal mains voltage 0 ... + 15 % [3]	About 70 - 100 mA at 2 V/cell	About 250 mA at 2 V/cell
Nominal voltage	4 V 6 V 8 V 12 V	4 V 6 V 8 V 12 V
Current limit	About 100 mA	—
Short-circuit protection	By fold back current limiting	By switching off
Short circuiting current	50 mA approx.	2 mA approx.
Overheating protection	Electronic	—
Wrong polarity protection	Electronic	Electronic
Reverse discharge of battery in case of mains failure	6 mA approx.	6 mA approx.
Output voltage	2.30 V ± 50 mV/cell [2]	2.30 V ± 50 mV/cell [2]
Deviation of output voltage on load	40 mV/cell approx. for half nominal current at 220 V mains voltage	
Deviation of output voltage with variations of mains voltage	± 10 mV/cell approx. for variations of mains voltage of ± 10 %	
Ripple voltage	Smaller than 50 mV$_{pp}$/cell at nominal current [2]	Smaller than 50 mV$_{pp}$/cell at nominal current [2]
Temperature stability	Less than 0.05 %/°C	Less than 0.05 %/°C
Environmental temperature range	0 °C ... + 45 °C	0 °C ... + 45 °C

1. In versions without the casing, the deviation can be reduced to about 2 mV by separate routing of the voltage sensor leads.

2. Only applies to battery operation.

3. The current quoted for a countervoltage of 2.3 V/cell is also the maximum permissible consumer current in stand-by parallel operation.

dryfit-system maintenance-free

Charging technique

ULIMATIC 800 mA	ULIMATIC 2,5 A	ULIMATIC 5 A	ULIMATIC 10 A
90 x 69 x 148 mm	162 x 110 x 280 mm	265 x 172 x 364 mm	265 x 172 x 364 mm
2 - 12 V 0.9 kg approx. 18 - 24 V 1.1 kg approx.	6 V 4.4 kg approx. 12 V 4.9 kg approx. 24 V 5.6 kg approx.	6 V 7.7 kg approx. 12 V 9.3 kg approx. 24 V 11.3 kg approx.	6 V 10.8 kg approx. 12 V 12.8 kg approx. 24 V 14.5 kg approx.
	150 x 100 x 220 mm	250 x 159 x 280 mm	250 x 159 x 280 mm
	6 V 2.4 kg approx. 12 V 2.9 kg approx. 24 V 3.6 kg approx	6 V 4.5 kg approx. 12 V 6.1 kg approx. 24 V 8.1 kg approx.	6 V 7.6 kg approx. 12 V 9.6 kg approx. 24 V 11.3 kg approx.
Ultramid B 3 S	Cover and chassis 3 mm aluminium. Base galvanised 1.25 mm steel sheet	Cover 2 mm aluminium, chassis 3 mm aluminium; Base galvanised steel 1.25 mm sheet	
Cover light grey Base slate grey	Cover RAL 7016. Structure base and chassis RAL 7035 glossy		
220 V 50/60 Hz or 110/220 V 50/60 Hz switchable. Voltage tolerance ± 10%	110/220 V switchable − 10%... + 15% 50/60 Hz at − 15% tolerance with reduced power		
Charge monitoring display from 5 mA approx.	Ammeter, charge monitoring display from 300 uA, terminal sockets, illuminated mains voltage switch, mains fuse, mains voltage change-over switch on the printed circuit board.		
—	—	Yes	Yes
0.1 - 0.3 A at 2.3 V/cell 0.4 - 0.6 A at 2.0 V/cell	1.25 A at 2.3 V/cell 2.00 A at 2.0 V/cell	2.5 A at 2.3 V/cell 4.0 A at 2.0 V/cell	4 A at 2.3 V/cell 6 A at 2.0 V/cell
0.3 - 0.4 A at 2.3 V/cell 0.6 - 0.8 A at 2.0 V/cell	2.00 A at 2.3 V/cell 2.50 A at 2.0 V/cell	4.0 A at 2.3 V/cell 5.0 A at 2.0 V/cell	6 A at 2.3 V/cell 8 A at 2.0 V/cell
0.4 - 0.6 A at 2.3 V/cell 0.8 - 0.9 A at 2.0 V/cell	2.50 A at 2.0 - 2.3 V/cell	5.0 A at 2.0 - 2.3 V/cell	10 A at 2.0 - 2.3 V/cell
2 V 4 V 6 V 8 V 12 V 18 V 24 V	6 V 12 V 24 V	6 V 12 V 24 V	6 V 12 V 24 V
800 - 1000 mA	2.5 - 2.7 A	5 - 5.5 A	10 - 11 A
By fold back current limiting starting below 1 V/cell approx.			
0.8 A approx. pulsating, switching off on 2 V and 4 V units	0.2 . . . 0.5 x nominal current	0.2 . . . 0.5 x nominal current	0.2 . . . 0.5 x nominal current
Electronic	Electronic	Electronic	Electronic
Electronic	Electronic	Electronic	Electronic
1 - 5 mA	Less than 0.2 mA	Less than 0.5 mA	Less than 1 mA
2.30 V ± 30 mV/cell	2.30 V ± 5 mV/cell	2.30 V ± 5 mV/cell	2.30 V ± 5 mV/cell
30 - 60 mV total for 0.4 A load nominal mains voltage	Less than 10 mV total	Less than 10 mV total [1]	Less than 20 mV total [1]
± 10 mV max. total for variations of mains voltage of ± 15%	Less than 1 mV total for variations of mains voltage of ± 15%		
1 - 5 mV_{pp}/cell at 0.4 A and nominal mains voltage, 10 - 50 mV_{pp}/cell at nominal current [2]	Less than 3 mV_{pp} total at 2.30 V/cell	Less than 5 mV_{pp} total at 2.30 V/cell	Less than 5 mV_{pp} total at 2.30 V/cell
Less than 0.05 %/°C	Less than 0.005 %/°C	Less than 0.005 %/°C	Less than 0.005 %/°C
− 20 °C . . . + 45 °C	− 20 °C . . . + 45 °C	− 20 °C . . . + 45 °C	− 20 °C . . . + 45 °C

![Sonnenschein logo]